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T. A. A. BROADBENT, M.A.

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The Mathematical Association.

THE ANNUAL MEETING will be held at the Institute of Education, Southampton Row, London, W.C. 1, on *Tuesday, 4th January*, 1938, and *Wednesday, 5th January*, 1938.

THE MATHEMATICAL ASSOCIATION, which was founded in 1871, as the *Association for the Improvement of Geometrical Teaching*, aims not only at the promotion of its original object, but at bringing within its purview all branches of elementary mathematics.

Its purpose is to form a strong combination of all persons who are interested in promoting good methods of teaching mathematics. The Association has already been largely successful in this direction. It has become a recognised authority in its own department, and is continuing to exert an important influence on methods of examination.

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The *Gazette* contains—Articles, Notes, Reviews, etc., dealing with elementary mathematics, and with mathematical topics of general interest.

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T. A. A. BROADBENT, M.A.

62 Coleraine Road, Blackheath, London, S.E. 3

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Vol. XXI. December, 1937. No. 247

SOME LINGUISTIC ASPECTS OF MATHEMATICAL TEACHING.

By M. Black.

The connection between thought and its expression in symbolism is perhaps more important in mathematics than in any other subject, for the complexity of mathematical thinking soon makes reference to symbolism an indispensable method of learning and discovery. This is true both in the historical development of the science and in the experience of the individual student. Without visible symbolism to act as a scaffolding, the sheer complexity of the subject matter results very soon in an incoherence and breakdown of the thinking process. While this is true to some extent of all subjects of any high degree of complexity, in mathematics a new and extremely interesting element enters into the situation. For the high regularity of mathematical processes and the wonderful adequacy of the symbolism produced in the course of thousands of years of development results in the fact that the symbolism itself can function almost without reference to the thought which originated it. The symbolism or calculus becomes a kind of machine manipulated according to fixed rules with no explicit reference to the thinking of which it is the product. This automatic aspect of mathematics is of the most fundamental importance in its development. The employment of mathematical machinery releases the energy of the mathematician for more complicated thinking at higher levels. Thus the invention of a mechanical symbolism is a mathematical discovery of the first importance. It both includes investigation of the relations in a certain field, and acts as a base for discoveries in other ever-widening fields. Striking examples of the manner in which mechanisation of thought fosters discovery can be found in every department of the mathematical sciences. It may be sufficient here to mention the invention of the analytical method in geometry by Descartes, and the differ-

ential and integral calculus by Leibnitz and Newton. The invention of mechancial symbolism may often suggest further relationships. As Laplace says : " Algebraical analysis soon makes us forget the principal object of our researches, leading us to be occupied with abstract combinations. It is not till the end that we are led back to our real destination. But by abandoning oneself to the operations of the analysis, the generality of the method and the inestimable advantage of being able to transform deductions into mechanical procedures often leads one to results which geometrical synthesis cannot achieve ". (*Exposition du système du monde*, 1799, Book V, Chap. V.) This " inestimable advantage " of mechanical procedures in mathematics is however a great danger both to learners and to teachers of the subject. For the mechanical process can all too easily be regarded as the sole object of study rather than a transitory phase in the movement from thought of a relatively simple to thought of a relatively complex order. Perhaps no experienced teacher of mathematics is unconscious of this danger, but remedies are not easy to propose. Especially for the child who could not be expected to know the historical value of the mechanisation of thinking processes, mathematics is too often apt to appear as a meaningless game played with mysterious symbols for an incomprehensible end.

It is suggested that one method of preventing this unfortunate but widespread attitude towards mathematics is to develop gradually an explicit awareness of the function of mathematical symbolism. This aspect of mathematical education would have as its aim the humanising of mathematical symbolism by explaining its purpose and history. Special emphasis would be laid on the fact that a system of marks needs a " sayer " and a " sayee " (in Butler's phrase) in order to become a symbolism, *i.e.* an instrument for the communication of thoughts. Study of the mathematical symbolisms of previous cultures, their purpose and limitations, would go far to remove the belief in the absolute nature of the elementary mathematics taught in schools. A course of this kind might include such topics as primitive methods of counting, the invention of counting in groups, the abacus, the invention of zero, traditional notation, the decimal system, the invention of x, complex numbers, etc. The treatment should, ideally, be a blend of history, linguistics and mathematics. It is hoped, in a future article, to outline the syllabus for such a course in more detail. Short of a programme as elaborate as this, however, much can be done in the ordinary course to point out that the language which mathematical thinking needs for its appropriate expression is not something completely strange and artificial, but has developed naturally out of the language of everyday experience. There is no rigid boundary, for instance, between mathematical language and English ; the characteristic and terrifying symbols of algebra are capable of exact translation into everyday speech. Thus to take the simplest but not the least important example, the symbol x or y is simply a more concise and visually expressive way of saying " some number or other, we don't know which ".

To almost every grammatical term or category in the English of everyday life corresponds a similar distinction in algebraical terminology. We may mention here parallels between punctuation and bracketing, between sentences and steps in a proof, between a question and an equation.

If explicit attention is paid to these links between algebra and everyday language; if, as occasion arises, some mention is made of the very gradual process by which these mathematical symbols replaced their more clumsy verbal equivalents; if, throughout the course, a deliberate attempt is made to strengthen the connection by giving exercises in the translation of algebra into English, much will be done to humanise the study of what to some people appears a terrifying subject. From another point of view the teacher of mathematics has much to gain by such a connection with linguistic studies. The habits of exact expression and of a sensitive attention to symbols which is part of the work of a teacher of English or of foreign languages, would be of more value to the teacher of mathematics if such attitudes and habits could also be transferred to mathematics. Recent psychological research has shown that such transfer is most likely to occur when explicit attention is drawn to the common ideas and subject matter of the two fields. Thus in the end less time will be needed than the reader might at first suppose. If —to whatever extent—the air of mystery can be removed from the subject of algebra, the increased interest should more than compensate for the time spent in such excursions.

Such work will be most effective if it can be done by systematic co-operation between teachers of mathematics and teachers of English. It will not be sufficient for the mathematician to point out that his pupils are writing sentences, making statements, analysing the same kind of logical relations as have already been met in grammar; it will be necessary also for the teacher of English, as opportunity arises, to use mathematical as well as non-mathematical examples. The child must never be allowed to forget that mathematics is expressed in a language, which is contiguous with and grows out of the ordinary non-technical language of everyday affairs.

The danger of degrading a process of education into the most futile form of machine-minding is greatest in elementary algebra, where the process of mechanisation has been carried to the utmost. In school geometry on the other hand, it is traditional to apply a mixture of synthesis and analysis in which the former predominates. Thus there is less scope for the teaching of highly formalised thought processes, and the possibilities of correlation with English are of a rather different kind.

The early stages of geometry are best regarded as an introduction to the simplest kind of physics; there is no reason to draw a sharp distinction between, for example, plane geometry and kinematics. That geometry is a branch of physics is, however, by no means widely accepted in pedagogical and philosophical literature; for the extreme simplicity of the experiments which can be performed in elementary

geometry, and the success with which a comparatively simple apparatus of concepts and laws can be applied to a highly complex field, has tended to obscure the experimental side of geometry, which brings it into direct relation with the other natural sciences, and to throw all emphasis on the purely deductive aspect. Once, however, the affinity of geometry and the other natural sciences is recognised and stressed in the early stages of the subject, as much attention will be paid to problems of description as to problems of deduction. The two are, of course, complementary and not mutually exclusive; those who prefer to regard the teaching of geometry above all as a training in pure deduction will still be faced again and again by the need for training their pupils in the exact description of geometrical configurations. Work of this kind will arise in almost every lesson, and geometry would gain by correlation with the training in description which is a valuable part of the work in English.

Geometrical material has a special value as material for exercise in the exact use of the English language to describe an objective situation. The description of a state of mind, though it need be no less objective than the description of a parallelogram, is apt to appear so to the child, and the teacher's valuation of attempts at such description is bound to appear, therefore, an arbitrary judgment. An emotion cannot be exhibited for comparison with its description. In geometry, however, it is very easy to convince a child of the adequacy, still more often of the inadequacy, of his description. The figures exactly corresponding to his attempted description can be drawn, its inadequacy shown in detail, and used as a base for an improved description, that is to say, for an improved use of language.

These virtues arising out of the simplicity of geometrical subject matter should recommend its use to teachers of English. Examples such as the description of a regular pentagon, of a cone or other solid bodies, provide suitable material. Exercises of this sort have more than a formal importance. Their material enters directly into many everyday situations; deciphering a knitting pattern, giving directions to a stranger, are exercises in applied descriptive geometry. It need hardly be added that such exercises should be carefully graded and composed by teachers of mathematics and English in consultation. Their effectiveness will be much increased if explicit attention is drawn to the purpose of their introduction. It might be feasible to encourage an ideal of virtuosity in description, beginning with the simplest geometrical configurations and ending with figures like a helical screw which tax the resources of the language and the skill of the teacher.

In this and other ways it should be possible, by stressing the relationships between mathematics and linguistic studies, to do something to remove that attitude towards mathematics which begins by regarding it as a mystery *sui generis* and ends by disliking it for that very reason.

M. B.

FALLACIES CONCERNING AVERAGES.

By H. T. H. Piaggio.

The County Cricket Championship table that appeared on 16th June disclosed a paradoxical state of affairs, which, when examined closely, is shown to depend upon the neglect of an important statistical principle used in the calculation of death-rates, comparative wage-rates, index numbers, and other data not usually associated with our national game. Sussex and Yorkshire had each completed seven matches, and each had won six and lost one. As for the unfinished matches, Sussex had four times led on the first innings and once been behind, while Yorkshire had been behind on the first innings in the only two unfinished matches they played. Thus on the complete matches the two counties were exactly equal, while on the unfinished ones Sussex had done better. Yet by the accepted method of calculation (15 points for a win, 5 for a first innings lead, 3 for a first innings without the lead, and 4 for no result), Sussex scored $(6\times 15)+(4\times 5)+(1\times 3)=113$ points out of a possible $12\times 15=180$, an average of 62·77 per cent., while Yorkshire scored $(6\times 15)+(2\times 3)=96$ points out of a possible $9\times 15=135$, an average of 71·11 per cent. If, however, we take the completed and unfinished matches separately, for the completed matches both counties scored 90 points out of a possible 105, or 85·71 per cent., while for the unfinished matches Sussex scored 23 points out of 75, or 30·67 per cent., but Yorkshire only 6 out of 30, or 20 per cent.

Consider now a problem concerning death-rates. Let S and Y denote two imaginary counties.* In S there are two age groups, the numbers in which are in the ratio 7 to 5. The death-rates per thousand in these groups are respectively 857·1 and 306·7. What is called the *crude death-rate* for the county is computed from the formula $\Sigma(pd)/\Sigma p$, where p is the proportionate number in an age group and d the death-rate in that group. Thus for county S the crude death-rate is $(7\times 857{\cdot}1)+(5\times 306{\cdot}7)/(7+5)=627{\cdot}7$. The corresponding calculation for county Y, in which the numbers in the two age-groups are in the ratio 7 to 2 and the death-rates in the group 857·1 and 200 respectively, gives the higher figure of 711·1. In this case it is clear that county S is really the most unhealthy. The apparent superior deadliness of Y arises only from the crude nature of the calculation, which ignores the disparity in size of the corresponding age-groups. In the words of C. Jones (*A First Course in Statistics*, p. 33): " to insure a fair comparison it is usual in the Reports of the Registrar-General to give a corrected death-rate in place of the crude death-rate defined above ". One method of doing this is to take the age-groups of the county Y as

* The counties and statistics in this paragraph are entirely fictitious and have no relation to any living or dead person. The abnormally high mortality is attributed to an imaginary disease (cricket fever).

standard (though, of course, it would be better to take those of the whole country), and to apply these age-groups to the county S as well as to Y. The final figure for Y is 711·1 as before, but that for S now comes to $(7 \times 857{\cdot}1) + (2 \times 306{\cdot}7)/(7+2) = 734{\cdot}8$.

Now let us take a third problem concerning the wage-rates in two countries (also entirely imaginary), which we will call S and Y. In S there are 7 million skilled men with an average wage of £85·71 per year and 5 million unskilled with an average wage of £30·67 per year. The corresponding figures for Y are 7 million skilled at an average of £85·71 per year and 2 million unskilled at only £20 a year. It is clear that the skilled men are paid at the same rate in both countries, while the unskilled are paid more highly in S. Yet if we calculate the average wage in the usual manner, it comes to £62·77 per year in S and to £71·11 in Y. These figures give a misleading impression, and to correct them economists compare Y's £71·11 with the weighted average formed from Y's wage-groups combined with S's wage. This gives a " corrected average " for S of $(7 \times 85{\cdot}71) + (2 \times 30{\cdot}67)/(7+2) = £73{\cdot}48$ per year.

The problem of index numbers is, roughly, to compare the average cost of living at the present day with that at some standard date. The difficulty is that not only do prices vary differently for different commodities, but the proportion in which those commodities are consumed also varies. One method of overcoming the difficulty is to use the proportions of the standard year in both cases.

It will be seen that all these problems are closely parallel. The moral is—but on second thoughts it will be safer to omit the moral, considering what happened when I started to discuss the matter with the vice-president of a certain cricket club! Readers will please note that I have no connection with either Sussex or Yorkshire, counties which are mentioned in alphabetical order, and moreover that I know nothing about cricket, and probably should never have noticed the championship table if it had not been pointed out and explained to me by the Rev. H. M. Blackett, M.A.

H. T. H. Piaggio.

GLEANINGS FAR AND NEAR.

1155. As poet *and* mathematician, he would reason well; as mere mathematician, he could not have reasoned at all, and thus would have been at the mercy of the Prefect.—E. A. Poe, *The Purloined Letter*. [Per Mr. B. A. Swinden.]

1156. During the latter part of the last century, the question arose among mathematicians—" to determine the best form that can be given to the sails of windmills, according to their varying distances from the revolving vanes, and likewise from the centres of revolution " . . . an excessively complex problem . . . and when at length an undeniable solution was discovered, men found that the wings of a bird had given it with absolute precision.—E. A. Poe, Footnote to *The Thousand-and-Second Tale of Scheherazade*. [Per Mr. B. A. Swinden.]

ON HOMOGENEOUS COORDINATES.

By A. Narasinga Rao.

1. In plane Analytical Geometry we use either two coordinates x, y or three homogeneous coordinates X, Y, Z connected by an identical relation

$$\alpha X+\beta Y+\gamma Z=1. \qquad (1.1)$$

These latter are usually interpreted either

(i) geometrically, as the distances of the point (taken with proper signs) from three straight lines, multiplied respectively by certain constants; or

(ii) algebraically, as an abridged notation in which X, Y, Z stand for certain linear expressions in the x and y.

In this note, I propose to discuss a third interpretation which appears to be fruitful, namely,

(iii) X, Y, Z may be conceived as the coordinates of a point on a plane p whose equation is $\alpha X+\beta Y+\gamma Z=1$ imbedded in a suitably chosen three-space S_3.

Such an interpretation enables us to pour into the geometry of the plane treated by homogeneous coordinates, the results and the suggestions acquired in the geometry of space. It is only necessary to link the metrical structure in the homogeneous coordinates X, Y, Z on the plane with that of the S_3 with non-homogeneous coordinates X, Y, Z so that the former may be the one induced on the plane by immersion in the latter.

2. To any homogeneous equation $f(X, Y, Z)=0$ corresponds a cone in S_3 with the origin for vertex, and its intersection with the plane (1.1) is a curve represented by the same equation in homogeneous coordinates X, Y, Z on the plane. In particular, since $\alpha X+\beta Y+\gamma Z=0$ is a plane parallel to p it follows that

$\alpha X+\beta Y+\gamma Z=0$ *is the equation of the line at infinity on* p. ...(2.1)

Again, let the angles between the axes of coordinates in S_3 be ω_{12}, ω_{23}, ω_{31}, so that the distance between two points is given by

$$d^2=\Sigma(X-X')^2+2\Sigma(Y-Y')(Z-Z')\cos\omega_{23}. \qquad (2.2)$$

This formula applies equally to the plane (1) *immersed in* S_3, the only specialisation being the additional relation

$$\alpha(X-X')+\beta(Y-Y')+\gamma(Z-Z')=0. \qquad (2.3)$$

which follows from the identical relation (1.1) satisfied by all points on the plane. Applying (2.2) to the vertices A, B, C of the reference triangle $(1/\alpha, 0, 0)$, $(0, 1/\beta, 0)$, $(0, 0, 1/\gamma)$ in pairs, we get

$$a^2=\frac{1}{\beta^2}+\frac{1}{\gamma^2}-\frac{2}{\beta\gamma}\cos\omega_{23} \qquad (2.4)$$

and two similar relations, a, b, c being the sides of the triangle.

With the help of (2.4) we may express $\cos\omega_{23}$, etc., in terms of the

sides of the reference triangle, and then utilise (2.3) to express the square terms $(X-X')^2$, etc., in terms of the products $(Y-Y')(Z-Z')$, etc., or *vice versa*. We thus obtain the two formulae *

$$d^2 = -\Sigma a^2\beta\gamma(Y-Y')(Z-Z'), \qquad (2.5)$$

$$d^2 = \tfrac{1}{2}\Sigma\alpha^2(b^2+c^2-a^2)(X-X')^2 \qquad (2.6)$$

$$= \Sigma\alpha^2 bc\cos A\,(X-X')^2, \qquad (2.7)$$

obviously we may get others by combining these two in various proportions as it were. The significance of this is that *there exist several metrics in the ambient S_3 which will induce the same metric in the plane p and that* (2.5) *and* (2.7) *give two such which are highly specialised.* The first of these corresponds (since the square terms are missing) to a reference frame in S_3 whose three axes are all isotropic lines. Interpreting (2.7) similarly we have the following very useful

CORRESPONDENCE PRINCIPLE. *The homogeneous coordinates XYZ of a point, subject to the relation* (1.1), *may be interpreted as Cartesian rectangular coordinates in a three space S_3, in which the units of length used along the X, Y and Z axes are respectively*

$$\alpha\sqrt{(bc\cos A)},\ \beta\sqrt{(ca\cos B)},\ \gamma\sqrt{(ab\cos C)}.$$

THE ANGULAR METRIC.

3. The line $lX+mY+nZ=0$ in the plane p is to be considered in S_3 as the intersection of the planes $\Sigma lX=0$ and $\Sigma\alpha X=1$ and is thus associated with the direction ratios λ, μ, ν where

$$\lambda:\mu:\nu = m\gamma-n\beta : n\alpha-l\gamma : l\beta-m\alpha. \qquad (3.1)$$

The direction ratios of all lines will thus satisfy the identical relation

$$\lambda\alpha+\mu\beta+\nu\gamma=0. \qquad (3.2)$$

To find the condition of orthogonality of two lines we obtain their direction ratios by (3.1) and apply the three-dimensional condition for orthogonality for the metric (2.7) which is

$$\lambda\lambda'\alpha^2 bc\cos A+\mu\mu'\beta^2 ca\cos B+\nu\nu'\gamma^2 ab\cos C=0,$$

thus giving $\Sigma\alpha^2 bc\cos A\,(m\gamma-n\beta)(m'\gamma-n'\beta)=0$. This is equivalent to the well-known form

$$\sum\frac{a^2ll'}{\alpha^2}-\sum\frac{(mn'+m'n)bc\cos A}{\beta\gamma}=0. \qquad (3.3)$$

To demonstrate the utility of the Correspondence Principle, I shall discuss two problems which usually offer considerable resistance to a treatment by homogeneous coordinates—the determination of the lengths of the principal axes of a conic, and a method for finding lengths and areas by integration.

* *Vide* Ferrers, *Trilinear Coordinates*, Chap. I, § 4.

Principal Axes of a Conic

4. Let the conic be given by

$$AX^2 + \dots \dots + 2FYZ + \dots \dots = 0. \qquad (4.1)$$

We interpret (4.1) as the equation of a cone which is cut by the plane $\Sigma\alpha X = 1$ in the required conic, and subject both these equations to the transformation :

$$\begin{aligned} x &= X\alpha\sqrt{bc \cos A} & y &= Y\beta\sqrt{ca \cos B} & z &= Z\gamma\sqrt{ab \cos C} \\ &= Xk_1 ; & &= Yk_2 ; & &= Zk_3 \text{ (say)}. \end{aligned} \qquad (4.2)$$

This reduces the metric (2.7) to $(x-x')^2 + (y-y')^2 + (z-z')^2$ so that the x, y, z system of rectangular coordinates is the usual one in which the same unit is used along the three axes. The equations of the cone (4.1) and the plane now become

$$A_1x^2 + \dots \dots 2F_1yz + \dots \dots = 0, \qquad (4.3)$$

and
$$\alpha_1 x + \beta_1 y + \gamma_1 z = 1, \qquad (4.4)$$

where
$$A_1 = A/k_1^2 ; \ F_1 = F/k_2k_3 ; \ \alpha_1 = \alpha/k_1, \text{ etc.} \qquad (4.5)$$

The axes of the conic are now obtained by the known formula * for the semi-axes of section of (4.3) by (4.4) and their squares are given by

$$\begin{vmatrix} A_1 + \frac{\lambda}{r^2} & H_1 & G_1 & \alpha_1 \\ H_1 & B_1 + \frac{\lambda}{r^2} & F_1 & \beta_1 \\ G_1 & F_1 & C_1 + \frac{\lambda}{r^2} & \gamma_1 \\ \alpha_1 & \beta_1 & \gamma_1 & 0 \end{vmatrix} = 0, \qquad (4.6)$$

where

$$\lambda = \begin{vmatrix} A_1 & H_1 & G_1 & 0 & \alpha_1 \\ H_1 & B_1 & F_1 & 0 & \beta_1 \\ G_1 & F_1 & C_1 & 0 & \gamma_1 \\ 0 & 0 & 0 & 0 & -1 \\ \alpha_1 & \beta_1 & \gamma_1 & -1 & 0 \end{vmatrix} \div \begin{vmatrix} A_1 & H_1 & G_1 & \alpha_1 \\ H_1 & B_1 & F_1 & \beta_1 \\ G_1 & F_1 & C_1 & \gamma_1 \\ \alpha_1 & \beta_1 & \gamma_1 & 0 \end{vmatrix}$$

$$= - \begin{vmatrix} A & H & G \\ H & B & F \\ G & F & C \end{vmatrix} \div \begin{vmatrix} A & H & G & \alpha \\ H & B & F & \beta \\ G & F & C & \gamma \\ \alpha & \beta & \gamma & 0 \end{vmatrix} \qquad (4.7)$$

on using the relations (4.5). The equation (4.6) after substitution from (4.5) simplifies into

* *Vide* Niewenglowski, *Cours de Géométrie Analytique* (1914), Tome III, p. 476.

$$\begin{vmatrix} A+\dfrac{\lambda\alpha^2bc\cos A}{r^2} & H & G & \alpha \\ H & B+\dfrac{\lambda\beta^2ca\cos B}{r^2} & F & \beta \\ G & F & C+\dfrac{\lambda\gamma^2ab\cos C}{r^2} & \gamma \\ \alpha & \beta & \gamma & 0 \end{vmatrix}=0, \quad \ldots(4.8)$$

where λ is given by (4.7). It is readily verified that for trilinear coordinates ($\alpha:\beta:\gamma=a:b:c$) this formula is identical with the one obtained by Ferrers.*

5. The determination of the length of an arc offers no special difficulty, since, if, X, Y, Z are the actual coordinates (satisfying $\Sigma\alpha X=1$), the correspondence principle gives

$$s=\int ds=\int (k_1^2dX^2+k_2^2dY^2+k_3^2dZ^2)^{1/2}.$$

This is essentially integration with respect to a single variable owing to the two relations $f(X, Y, Z)=0$ and $\Sigma\alpha X=1$.

Areas by Integration

To obtain the area of a closed curve we use the correspondence principle and obtain by the elimination of one of the variables between the two equations, the projection of the curve on one of the coordinate planes. Its area is calculated as usual and then multiplied by the secant of the angle between the planes. Thus the area of the closed curve $f(X, Y, Z)=0$ is given by the formula :

$$\begin{aligned}\text{Area} &= [k_2k_3\oint YdZ]\times\text{secant of the angle between } \Sigma\alpha X=1 \text{ and } X=0\\ &=[k_2k_3\oint YdZ]\times\sqrt{(\alpha/k_1)^2+(\beta/k_2)^2+(\gamma/k_3)^2}/(\alpha/k_1)\\ &=[\oint YdZ]\times\sqrt{\alpha^2k_2^2k_3^2+\beta^2k_3^2k_1^2+\gamma^2k_1^2k_2^2}/\alpha\\ &=4R^2\beta\gamma\sin A\sin B\sin C\oint YdZ\,; \quad \ldots(5.2)\end{aligned}$$

when the coordinates are trilinear, this reduces to

$$\operatorname{cosec} A\oint YdZ. \quad \ldots(5.3)$$

For example, let us find the area of the conic $2XZ=\lambda Y^2$ which is given parametrically by

$$X=t^2/D,\ Y=2t/D,\ Z=2\lambda/D\,;\ \ D=\alpha t^2+2\beta t+2\gamma\lambda.$$

Here $$\oint YdZ=-\int_{-\infty}^{\infty}\frac{4\lambda tD'dt}{D^3} \text{ where } D'=dD/dt$$

* Ferrers, *Trilinear Coordinates*, Chap. IV, § 21. For a derivation of the formula for the semi-axes of a quadric in S_n purely from dimensional consideration *vide*: Narasinga Rao, " On the form of the equation giving the axes of a quadric locus or envelope ". *Tohoku Math. Journal*, Vol. 31, p. 420 *et seq.*

$$=\left[\frac{2\lambda t}{D^2}\right]_{-\infty}^{\infty}-\int_{-\infty}^{\infty}\frac{2\lambda dt}{D^2}.$$

The first term on the right vanishes at both limits. We notice also that the condition for the convergence of the integral is that the roots of D should be complex, *i.e.* the curve should be an ellipse. In this case we evaluate the second term and obtain its value :

$$-\pi\alpha\lambda(2\lambda\alpha\gamma-\beta^2)^{-3/2}.$$

Hence by (5.2) the area of the conic is

$$4R^2\pi\lambda\alpha\beta\gamma \sin A \sin B \sin C/(2\lambda\alpha\gamma-\beta^2)^{3/2}.$$

This agrees with the value obtained from the product of the semi-axes as given by (4.8).

In particular if the coordinates are trilinear so that $\alpha:\beta:\gamma=a:b:c$ we have for the area :

$$\frac{4R^2\pi\lambda \sin^2 A \sin^2 B \sin^2 C}{(2\lambda \sin A \sin C-\sin^2 B)^{3/2}}.$$

A. N. R.

Annamalainagar, South India.

1157. We reverence ancient Greece as the cradle of western science. Here for the first time the world witnessed the miracle of a logical system which proceeded from step to step with such precision that every single one of its propositions was absolutely indubitable—I refer to Euclid's geometry. This admirable triumph of reasoning gave the human intellect the confidence in itself necessary for its subsequent achievements. If Euclid fails to kindle your youthful enthusiasm, then you were not born to be a scientific thinker.—A. Einstein, *The World as I see it.* [Per Mr. C. O. Tuckey.]

1158. From these studies I proceeded to elementary geometry, beyond which I never advanced, although I persistently attempted, in some degree, to overcome my weakness of memory by dint of retracing my steps hundreds of times, and by incessantly going over the same ground. I did not like Euclid, whose object is rather a chain of proofs than the connection of ideas. I preferred Father Lamy's "Geometry", which from that time became one of my favourite works, and which I am still able to read with pleasure. Next came Algebra, in which I still took Father Lamy for my guide. When I was more advanced, I took Father Reynaud's "Science of Calculation"; then his "Analysis Demonstrated", which I merely skimmed. I have never got so far as to understand properly the application of algebra to geometry. I did not like this method of working without knowing what I was doing; and it appeared to me that solving a geometrical problem by means of equations was like playing a tune by simply turning the handle of a barrel-organ. The first time that I found, by calculation, that the square of a binomial was composed of the square of each of its parts added to twice the product of those parts, in spite of the correctness of my multiplication, I would not believe it until I had drawn the figure. I had considerable liking for algebra, in so far as it dealt with abstract quantities; but, when it was applied to space and dimensions, I wanted to see the operation explained by lines; otherwise I was entirely unable to comprehend it.—*Confessions* of Jean Jacques Rousseau, Book VI. [Per Dr. J. McWhan.]

PRACTICAL PLANE AND SOLID GEOMETRY.*

BY F. G. SKRINE.

WHEN I was younger this was a very well-known subject, and actually was called Science Subject No. 1 in the days of the Board of Education's South Kensington Examination. Engineers (mechanical and civil) and craftsmen were taught it as a fundamental subject, and even teachers in training were expected to know something about it. The rise of Practical Mathematics put it into the background—wrongly I think—but there are signs that a healthy interest is being taken in this section again.

Practical Geometry has always appealed to the craftsman, probably because it could be more directly associated with everyday problems. This, together with a definitely practical treatment of the problems as they arose, quite possibly made the subject easier to assimilate than was the case with more abstract studies.

Speaking as a craftsman, I must say I have always had an idea that there is much valuable geometrical information that can be imparted by practical methods that cannot be reached by the present theoretical approach in the time available for Secondary or High School scholars. This time factor is important. In Solid Geometry especially, Practical Geometry should give the scholar much more than an abstract or numerical acquaintance. It should make him familiar with the shape of a solid and its constitution. If a solid has a developable surface he should be able to determine that development. It should also make him familiar with methods of exhibiting details of objects in plan, elevation, and section. Without stressing details at this point Practical Geometry should enable a scholar to approach the professional studies of the engineer, architect, surveyor and any other that would need the preparation and interpretation of drawings, with an appreciation not very readily available nowadays. To my mind it is foundation work that the schools should provide. Please do not misunderstand me, I am not suggesting shortcomings in the mathematical teaching, but an additional subject that will, I feel sure, be an amplification of the Mathematics and a valuable addition to the school curriculum.

In the Practical treatment of Geometry, accurate constructions based on definite theoretical truths are used, but no theoretical proofs are required. The actual accurate result shown in the drawing, which may be measured when measurement is desirable, is all we aim at. Of course the methods employed must be correct and capable of a theoretical proof, and not mere guesswork.

Some methods, allowable in a workshop, or a drawing office, which cannot be justified theoretically or educationally, are outside our consideration when drafting a school syllabus. For instance, in a drawing office if a circular arc to touch two lines is wanted, the centre is found by trial when the radius or other limitations are known. This

* A paper read at a meeting of the Cardiff Branch of the Mathematical Association.

is practically accurate and within workshop and drawing office needs, but is not permissible in a school course—the construction to find the centre must be used.

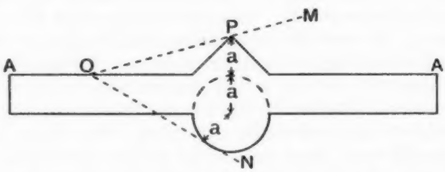
A few years ago Professor Livens outlined a scheme of instruction in Geometry, and—I am speaking from memory—in that scheme he suggested commencing with a couple of terms of playing about with compasses and ruler to familiarise the beginner with a few of the more obvious facts, relations and uses of these intruments. Here may I make a little confession; it was then I realised that I had been teaching Mathematics all my school life, because these suggestions and others made many points of contact between Professor Livens' course and the work and methods of my present subject.

While talking of instruments, it would be well if I made clear what I regard as permissible in Practical Geometry. The usual ones are Drawing Board, T-Square, 60° and 45° Set Squares, Protractor, Ruler (with inches decimally divided, and centimetres), and *good* Compasses and Dividers. An adjustable set square which has its hypotenuse pivoted so that it can be set to any angle, is a very useful instrument from the points of view of accuracy and time-saving. It is very valuable for drawing parallel, perpendicular and symmetrical lines quickly and accurately. Another very useful aid is a piece of tracing paper to be used for transferring shapes already determined in one part of a drawing to another position. In passing, this question of instruments has been a sore one with me for years. The *sets* sold in Educational Stationers for use in schools (usually Secondary and High Schools too) are really appalling. For years, at least one school in Cardiff sent boys on to me at the Technical College to Evening Classes after leaving school armed—I use the word with feeling—with set squares that had been stamped out of thick tinned plate, and compasses that were unbelievably decrepit and knock-kneed. Impossible things that they had used contentedly for a couple of years. Their astonishment that I was not satisfied would surprise you. I cannot too strongly emphasise the fact that this work must have accurate and reliable instruments. The pencil used *must be sharp*, and only a hard lead, say H, HH, or HHH, of good quality, can be relied on to keep a point good enough for the work. Here again, students have weird ideas. In the days when my boys found their own pencils, it was a common experience to find what I called "farthing change" pencils, soft and of poor quality that would draw lines that visibly thickened if they were more than an inch long. Copying leads were not unusual, and I *have* had a boy use a blue lead. Imagine it for work that I hope to be able to measure to 1/100th or even 1/200th of an inch! I should have mentioned a rubber, but in my experience boys will not need reminding about this.

Practical Plane and Solid Geometry has been accepted recently by the University of Wales as a Matriculation subject, and I propose to consider this syllabus and discuss points which I have found interesting in treatment or application.

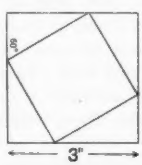
Plane Geometry.

Speaking generally there is very little in the Plane Geometry that can be very different in method from the constructions you must be familiar with in your theoretical study, but I expect we are a bit more sudden and direct in our treatment of a problem. There are a few problems, beautifully easy in theory, that present unexpected snags when attacked practically. An outstanding one in my experience is to draw an arc through three points when the points are as they presented themselves in a job that came my way many years ago. I had to mark out accurately an arc of a circle whose chord was 12′ 6″ and greatest height from the chord $1\frac{1}{2}$″. When calculated the radius is over 156 feet. Imagine yourselves in some wide open space trying to find the centre, and when you have found it, what are you to use for radius? On the other hand, it *is* possible that a practical solution is available long before theory would make one apparent. I came across a practical solution of the ages old problem of trisecting an angle in a book of puzzles. A special model used to solve the problem is of French origin and can be cut from cardboard in this manner.



If the model is placed on the angle MON to be trisected, with P touching MO, the circle touching ON, and the straight edge AA passing through O, the angle MON is trisected by AA.

Reading through the syllabus we have *the division of a straight line into equal parts and in a given ratio*, followed by *scales*. Both sections are so well known that we can pass on to the next which says *enlarging and reducing plane figures*. This is a rather interesting item. When the straight-forward examples are understood, I have emphasised the usefulness of the method as a means of solving problems not directly connected with it. A figure like this is easily

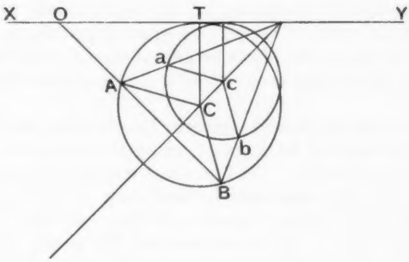


drawn if the inner square is drawn first and then the outer. The whole could then be enlarged or reduced to suit the given measurement.

A regular pentagon to a given height is very easily drawn with a little knowledge of the angles involved, I know, but I should be quite as satisfied with a method that drew a pentagon correctly to any size and then enlarged or reduced to the size required.

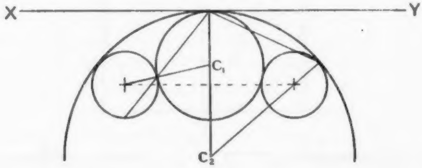
A teacher often works without seeing very much fruit for his labour, but I once had a very surprising application of this method of procedure. In a terminal examination paper I had set the problem : "Draw a circle passing through A and B and touching the line XY."

I expected the solution that used the mean proportional method $OT^2 = OA \cdot OB$, where O is the point in which AB produced meets XY, and OT is the tangent to the circle. On one paper I met this solution.



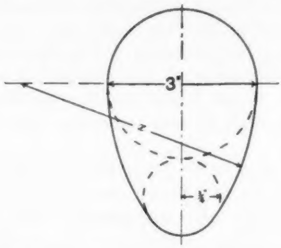
It is obvious now what was in the boy's mind but the solution was quite new to me and I have not met it in any textbook.

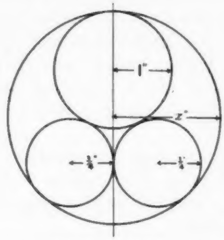
The next item in the syllabus is *setting out triangles, quadrilaterals, and polygons.* Nothing very unusual can be there. Then we come to *circles and lines in contact; applications to setting out.* A very important section from a *practical* standpoint. A very interesting group of problems under this head has this very ordinary one as the base of their solution.



The two given circles are equal in radius and the line joining their centres is parallel to XY. The problem is to draw a third circle to touch the given line and the two circles either internally or externally. Of course in practical work we have a big advantage when we substitute a diagram for a long, frequently misread or misunderstood

statement. We would merely say " set out the figure to the sizes given. Determine the radius x ". In, say, the following :

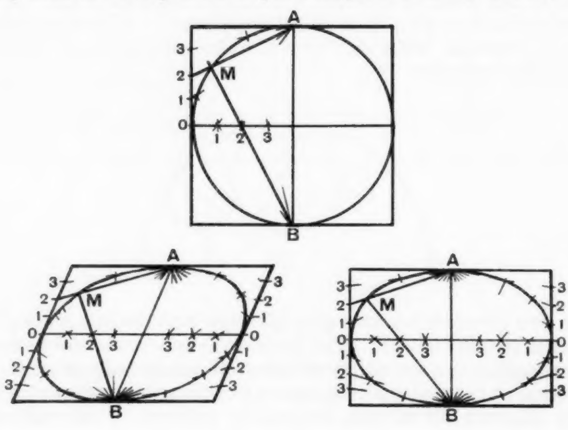




or a dozen others all wrapping up the same basic problem. The value of points of contact is obvious in such problems.

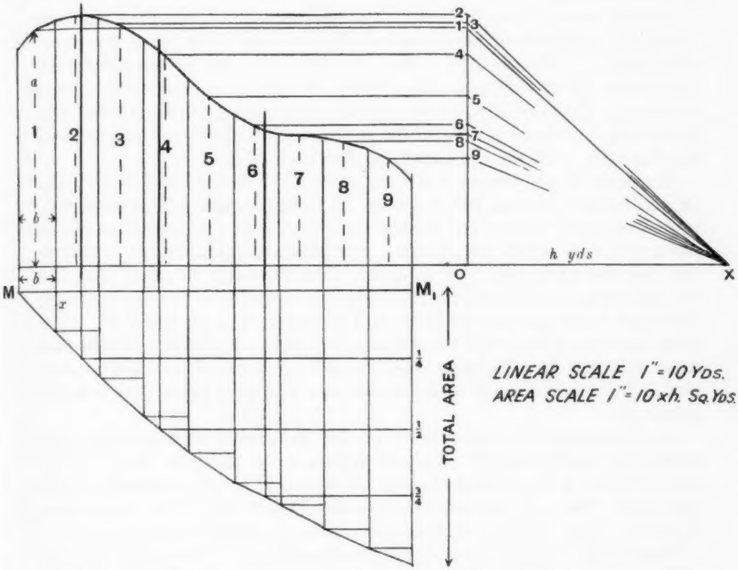
I must not dwell on the plane problems so will read the remainder of the syllabus and content myself with comments on two more items in the section.

The Ellipse is an important curve in Engineering and we use three or even four methods of setting out, using the one most suited to the conditions of the problem. (1) The short trammel is most frequently used, but (2) the long trammel is used only occasionally when the axes of the ellipse are nearly equal in length. (3) The string method is popular but cannot be recommended for really accurate work because it is difficult to keep the string at the same degree of tension. (4) Inscribed in a rectangle or parallelogram through points determined by intersecting lines. This method is easily made intelligible if the ellipse is regarded as the plan of a circle enclosed in a square and both inclined to the ground. The relation between the intersecting lines in the square and parallelogram is easily shown.



In teaching, the Plane and Solid sections would run concurrently, so that this procedure is quite possible.

The last item on the syllabus is interesting as I believe it is an instance where a practical method solves a problem that is extremely difficult when tackled by any other means. Shall I spend a few minutes with it?



It is required to find the area of the irregular figure and to divide into equal areas by straight lines perpendicular to its base line. The figure is divided into a number of equal strips and the centre line of each strip drawn. Then for strip 1 its area is very approximately ab when a is the length of the dotted centre line and b the width of the strip. To graph this area to a convenient scale, the length a is transferred to a parallel line outside the figure and a convenient distance h marked off, and a triangle completed by joining $1X$. Then if a base line MM_1 is taken and a parallel to $1X$ drawn from M it will cut the first ordinate, marking a length x. Comparing the two triangles it is easy to see that $x = ab/h$ and as ab is the area of the first strip, x represents this area divided by the polar distance h. This gives a scale that can be used to read the area from the ordinates. Continuing the process, the triangle for the second strip beginning where the first ends, and so on, we get a graph whose ordinate shows the growth of the area as we work from left to right.

The one to the extreme right is the total area. Division into equal

areas is readily done by dividing this line, and horizontals will indicate points on the area graph from which vertical lines will divide the figure as required. In short we use the Bending Moment diagram to sum and divide a plane area.

Solid Geometry.

It is in the portion of the syllabus headed Solid Geometry that the Practical methods of treatment and approach differ very considerably from the Theoretical. We use very early on, ideas and truths that must come very much later in a theoretical and strictly logical sequence. I do not suggest there is anything wrong in the theoretical approach, but there is very much that can be understood and applied intelligently without that gradual development.

The idea of projection is a very practical one and the underlying principles are very simple to grasp. A hinged board will readily convey to the eye the two commonly used planes of projection on which plans and elevations are drawn. For his own guidance the beginner can use the open pages of a book. The necessity of imagining the two planes laid out flat for convenience in drawing is soon recognised. The plan is drawn on the H.P. and the elevation on the V.P. It is often necessary to project auxiliary elevations to display details and when the fact that heights must be the same for all elevations projected from one plan is understood, the new projections are readily obtained.

Another important step is to be able to draw the projections of a section on a solid and from these to determine the true shape of the cut surface. I have used the square pyramid as an illustration (see opposite), but all prisms and pyramids are used for examples. Cylinder, cone, sphere, and simple made-up solids are also used.

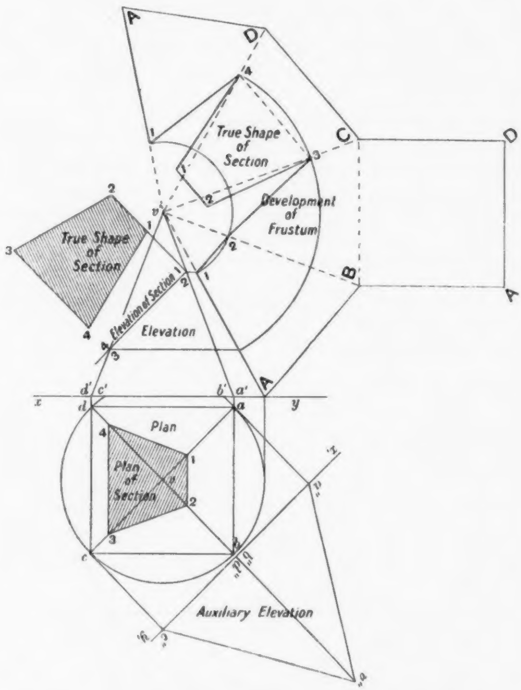
Then follows a very important practical aspect ; the development of the surfaces of each of these (omitting the sphere). The lines made by section planes on the surfaces of the cut solids must also be shown on the developments, and where a frustum only is required the true shape of the section transferred to its proper position in relation to the other surfaces of the solid.

We do not confine ourselves to the *right* prisms and pyramids. Oblique examples are very interesting, and there are many applications in practical work. The work involved is not difficult if the *right* solids have been understood.

Then when we have a fair knowledge of single solids we can take two of these intersecting and the curve of interpenetration between them makes a most intriguing exercise.

You will notice that points, lines, and planes take a secondary place in the work. We find that dealing with recognisable solids gives an easier approach and we leave this portion until the student has a working knowledge of projection. This, which is a more abstract business, does not then present so many difficulties. We cannot omit it, as there are several applications that make this work

valuable to the practical man. For instance, a roof involves applications of both lines and planes.



Under the heading of *isometric projection* we have a special projection in which the object is considered as being tilted so as to exhibit three mutually perpendicular faces equally inclined to the plane of projection. This gives a drawing in which the lines of intersection of these planes are themselves equally inclined and consequently diminish in equal ratio. This shortening may be ignored in a number of cases without affecting the value of the drawing. In fact the only solid that needs the scale is the sphere, and any object including a sphere or part of it, must be drawn to a correct isometric scale in order to exhibit the sphere in its proper relation to the others.

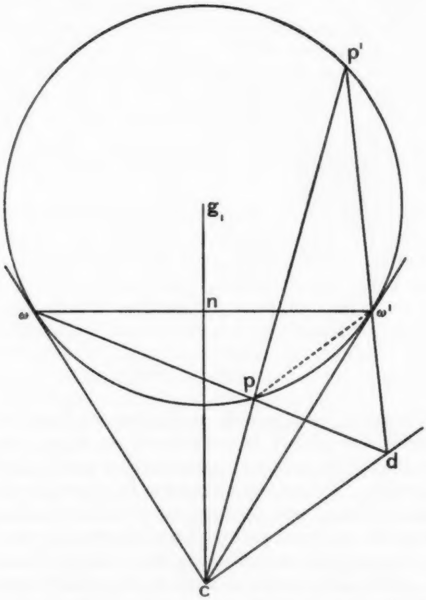
I think I have said enough to indicate the scope of the syllabus. Much could be said about its interest and practical value but that is another story. F. G. S.

THE CONJUGATE HYPERBOLA AND THE INVOLUTORY ELLIPSE.

By Rev. J. B. Freeman.

N.B.—In what follows we consider the conic as the projection of the circle and assume only its *descriptive* (including cross-ratio) properties as known.

1. A circle, centre g_1, is cut by a secant line at ww'. Any line cpp' through c, the pole of ww', cuts the circle at p and again at p'. The lines wp and $w'p'$ intersect at d. The locus of d for the variable secant line through c is a hyperbola touching the given circle at ww'. (If $w'p$ and wp' meet at d', the locus of d' is the same hyperbola.) This hyperbola will be called the *hyperbola conjugate to the given circle with respect to the given secant line ww'*.



Outline of proof. Since cpp' and $d'cd$ are conjugate lines with respect to the circle,

therefore $$w'(wpcd) = -1. \quad \text{.........................(1)}$$

Hence $w'p$, and $w'd$ are involution conjugates in the involution pencil having $w'w$ and $w'c$ as double lines. Let $p_1, p_2, p_3, p_4, \ldots$ and $d_1, d_2, d_3, d_4, \ldots$ be corresponding points.

It can be easily shown that

$$w(d_1'd_2'd_3' \ldots) = w(d_1d_2d_3 \ldots) = w'(d_1d_2d_3 \ldots) = w'(d_1'd_2'd_3' \ldots). \quad \ldots(2)$$

Hence by Chasles' theorem the locus of d is a conic. Again when p and p' coincide at w', d and d' also coincide at w'; hence the conic touches the circle at w', similarly at w.

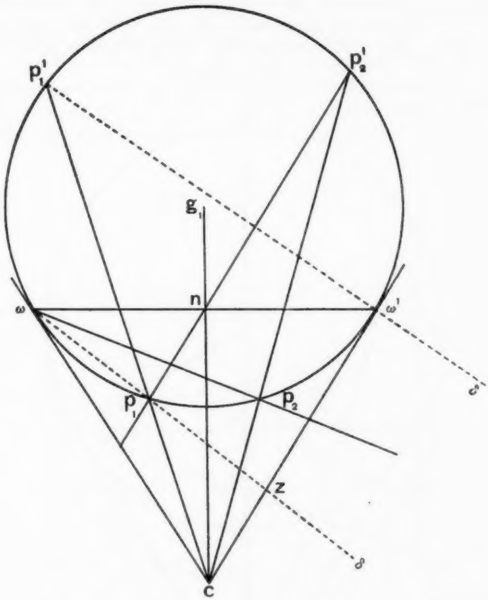
The conic has two real points at infinity, as shown in (2). Hence it is a hyperbola.

2. *To find the points at infinity on the conic.* Let cg_1 meet ww' at n. Through n draw a parallel to cw' to meet the circle at p_1p_2', p_1 being on the arc nearer to c.

Let cp_1 and cp_2' cut the circle again at p_1', and p_2 respectively.

Let δ be the point of intersection of wp_1 and $w'p_1'$.

Let wp_1 cut cw' at z.



Then p_1 is the mid-point of wz by parallels; and since

$$c(ww', p_1\delta) = -1,$$

therefore $(wz, p_1\delta) = -1$. But p_1 is the mid-point of wz; hence δ is at infinity.

Similarly it can be shown that if wp_2' and $w'p_2$ meet at δ', δ' is at infinity.

Hence the conic has two real points at infinity and is a hyperbola.

(It can be shown that p_2, n, p_1' are collinear, and the construction of drawing a parallel through n to cw gives us the line p_2np_1'. Hence we get only two real points at infinity δ and δ', as should be the case.)

NOTE. (i) It can be shown that $w'p_1=\frac{1}{\sqrt{2}}\, w'w$.

(ii) $w'p_1=wp_1'=w'p_2'=wp_2$.

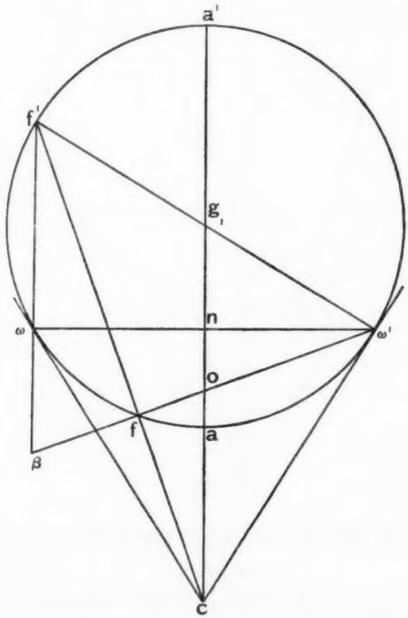
(i) Since p_1 is the mid-pt. of zw, therefore

$$w'w^2+w'z^2=2w'p_1{}^2+2p_1w^2.$$

But $w'z^2=zp_1 \,.\, zw=2p_1w^2$, so that $w'w^2=2w'p_1{}^2$.

(ii) For if in the above $w'p_1$ and wp_1' meet at ϵ, then ϵ, c, and δ are in a straight line; but δ is at infinity; hence $c\epsilon$ is parallel to wp_1 and to $w'p_1'$; also wp_1 and $w'p_1'$ are parallel chords of the circle.

Hence $$w'p_1=wp_1'.$$



3. If o be the harmonic conjugate of g_1 with respect to n and c, then o is the centre of the hyperbola. For o, the centre of the hyper-

bola, by symmetry, must lie on cg, *i.e.* the diameter aa' of the circle; and if o be the centre, and $w'q$ meet the conic again at β, then o is the mid-pt. of $w'\beta$. Let $w'o$ meet the circle at f, and let cf produced cut the circle again at f'. Then $f'w$ must meet $w'f$ at β from the definition of the conic. But since o is the mid-pt. of $w'\beta$ and n that of $w'w$, therefore βw is parallel to on. Hence $w'wf'$ is a right angle and $w'f'$ passes through g_1. (See figure opposite.)

But $\qquad w'(cw, ff') = -1.$

Therefore $\qquad (cn, og_1) = -1.$

That is, o is the harmonic conjugate of g_1 with reference to c and n.

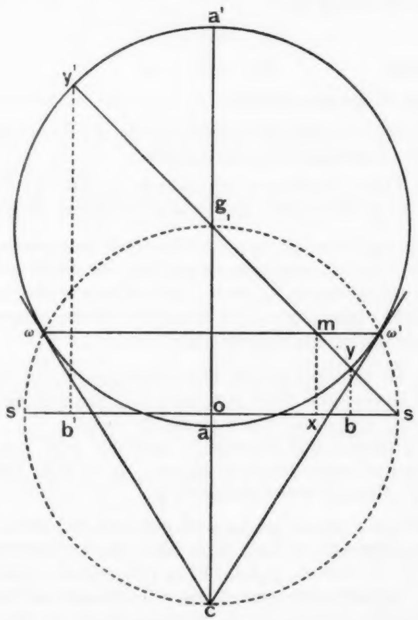
The method of proof also gives a construction to find o, the centre of the hyperbola.

NOTE. (i) It can be easily shown that o lies between a and n.

(ii) The *asymptotes* are lines joining o to the points δ and δ'.

4. *To find the foci and the directrices.* Draw the circle on g_1c as diameter to cut the line through o perpendicular to aa' at s and s'.

Join sg_1 to meet ww' at m and the circle at y and y'. Then the perpendiculars mx, yb and $y'b'$ to ss' are the directrix corresponding to s and the tangents at the vertices respectively.



Proof. The circle on g_1c as diameter and the straight line ww^1 are inverses with respect to the given circle, centre g_1.

Hence m and s are inverse points and $g_1m \,.\, g_1s = g_1y^2 = g_1y'^2$, so that

$$(yy',\, ms) = -1.$$

But $yw'y'$ is a right angle. Hence $w'y$ and $w'y'$ bisect internally and externally the angle $sw'm$; and

$$\frac{sw'}{w'm} = \frac{sy}{ym} = \frac{sy'}{my'}.$$

Since m and s are inverse points with respect to the original circle and g_1sc is a right angle, the polar of m with respect to this circle is cs. Hence cs and cm are conjugate lines with respect to the circle, hence with respect to the hyperbola also; (see note 5 below). That is, pole of cs with respect to the hyperbola lies on cm. But since cs passes through c, therefore the pole of cs with respect to the hyperbola lies on the polar of c with respect to the hyperbola, *i.e.* on ww'.

Hence pole of cs with respect to the hyperbola is m.

Hence sm and sc are conjugate lines for the hyperbola, and they are at right angles, and neither of them is the axis itself.

Therefore s is a focus. And since the pole of sc lies on the directrix, m is on the directrix. Hence mx, perpendicular to the axis ss', is the directrix corresponding to s.

Again $$(yy',\, ms) = -1,$$

and by parallels $$(bb',\, xs) = -1.$$

Hence b and b' are the vertices.

NOTE. (i) The construction gives us the two real foci and their corresponding directrices.

(ii) The hyperbola conjugate to a circle with respect to a given secant line is thus uniquely determined.

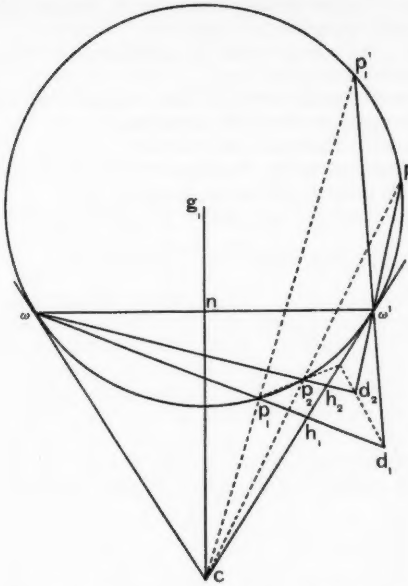
5. Lines through c conjugate for the circle are also conjugate for the hyperbola. For c is the pole of ww' for the circle and the hyperbola, and cw, cw' tangents to both; and if two such lines meet ww' at x and y, then $c(ww',\, xy) = -1$ from the circle. Hence cx and cy are also conjugate for the hyperbola.

6. If p_1, p_2 be two points on the circle and d_1, d_2 corresponding points on the hyperbola, then p_1p_2 and d_1d_2 meet either on cw or on cw'. Also $p_1'p_2'$ and $d_1'd_2'$ meet on cw or on cw'.

If cpp' be a secant line through c, and wp, $w'p'$ meet at d, then p and d are called *corresponding* points. It is clear that if wp' and $w'p$ meet at d', then d' corresponds to p'.

Proof. Let p_1d_1 cut cw' at h_1, and p_2d_2 cut cw' at h_2. p_1d_1 passes by definition through w and p_2d_2 also passes through w. Also $c(ww',\, p_1d_1) = -1 = c(ww',\, p_2d_2)$, hence $(wh_1,\, p_1d_1) = (wh_2,\, p_2d_2)$.

But these equicross ranges have a common self-corresponding point w; therefore p_1p_2 and d_1d_2 meet on h_1h_2, *i.e.* on cw'.



7. The tangents at corresponding points on the circle and the hyperbola meet on one of the tangents cw, cw'.

Let p_2 come to p_1 in the limit, then d_2 comes to d_1, and by note 6 the proposition follows.

8. Let the perpendicular through c to cg_1 cut the hyperbola at vv'. Then the polar of n—chord of contact of tangents from n to hyperbola —passes through c and is parallel to ww', since nc passes through o. Hence the chord of contact of tangents from n to the hyperbola is vv', *i.e.* nv, nv' are tangents from n to the hyperbola. Let a circle, centre g_2, touch nv, nv' at v and v'. The hyperbola touches this circle also at v and v'. n and c are limiting points for the two circles.

Also c is the mid-point of g_1g_2, and $cw=cw'=cv'=cv$.

Also $a'w'$ passes through v' and $a'w$ through v.

For let $a'w'$ and aw meet at v'.

Then from the quadrangle $a'w'aw$, v' lies on the polar of n with respect to the circle g_1.

Hence cv' is perpendicular to gn or g_1c.

The point v' corresponds to a.

Similarly v, the point of intersection of $a'w$ and aw', corresponds to a'. But the polar of c for the hyperbola passes through n. Therefore polar of n passes through c.

But the polar of n for the hyperbola must be at right angles to the conjugate axis of the hyperbola.

Hence polar of n for the hyperbola is vv' passing through c, and nv, nv' touch the hyperbola at v and v'.

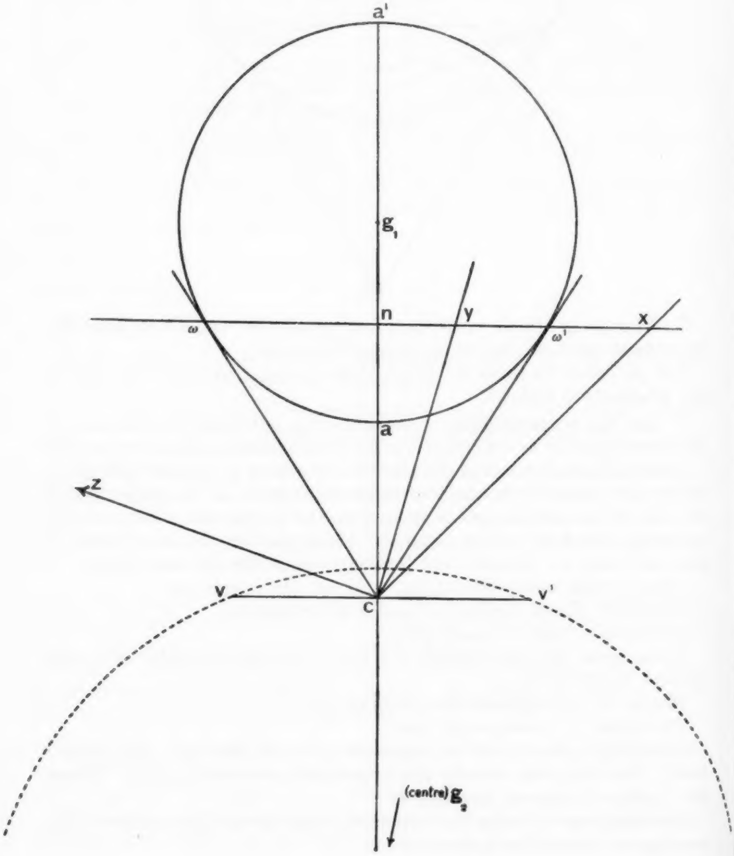
Again angle $cv'w'$ = angle $nw'a'$ by parallels
= angle nwa', since $a'w' = a'w$
= angle $cw'v'$ (angle between the tangent cw' and the chord $v'w'$ = angle in alternate segment).

Hence $cv' = cw'$. Thus $cw = cw' = cv = cv'$.

Draw the circle, centre g_2, touching nv, nv' at v and v'. g_2 lies on g_1c; n and c are inverse points for the circle g_2.

Hence n and c are limiting points for circles g_1 and g_2, and

$$cn \, . \, cg_1 = cw'^2 = cv'^2 = g_2c \, . \, cn.$$



Therefore $cg_1 = g_2c$, *i.e.* c is the mid-point of g_1g_2.

By note 7, the tangent $v'n$ meets the tangent at a' on cw'; the tangent vn meets the tangent at a on cw.

9. If cx be a line through c, and cy and cz be lines through c conjugate to cx for circles g_1 and g_2 respectively meeting ww' at y and z, then g_1y is parallel to g_2z. (See figure opposite.)

For if cx cuts ww' at x, then cxz is a triangle self-conjugate with respect to the circle g_2. Hence g_2 is its orthocentre and

$$cn \,.\, g_2n = -nx \,.\, nz.$$

But $$g_1n \,.\, nc = nw'^2 = nx \,.\, ny.$$

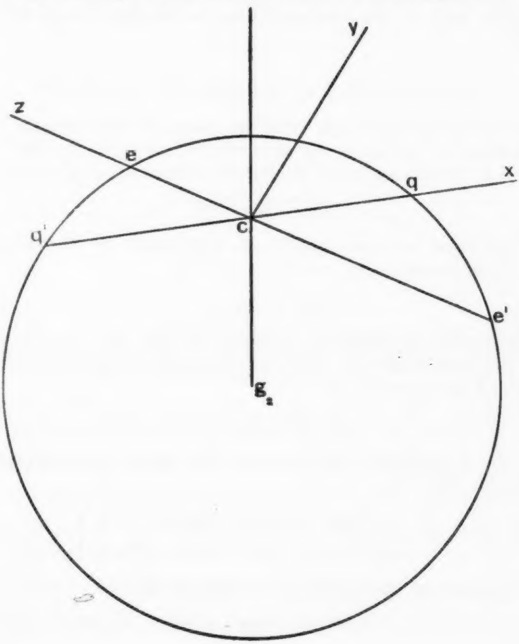
Hence $\dfrac{g_2n}{g_1n} = \dfrac{nz}{ny}$, or $\dfrac{g_2n}{nz} = \dfrac{g_1n}{ny}$, and g_2nz = a right angle $= g_1ny$.

Therefore g_1y is parallel to g_2z.

Aliter. g_1y is perpendicular to cx, since y is the pole of cx for circle g_1. Also g_2z is perpendicular to cx, since z is the pole of cx for circle g_2. Hence g_1y is parallel to g_2z.

10. If the conjugate lines cx, cz for the circle g_2 cuts the circle at qq' and ee' respectively, then wq and $w'q'$ meet on cy, viz. the line through c conjugate to cx for circle g_1.

Let cx cut ww' at x and cy cut ww' at y. Then $(qq', cx) = -1$, since the chord qq' through c cuts the polar of c for circle g_2 at x.



But $(ww', yx) = -1$, since cx and cy are conjugate lines for circle g_1, cutting the polar of c at x and y.

Hence $(qq', cx) = (ww', yx)$. These equicross ranges have a common self-corresponding point x.

Hence they are in perspective, so that wq and $w'q'$ meet on cy.

11. We can make use of the hyperbola to find the lines through c conjugate to the line cx for the two circles, when cx meets the hyperbola. Let cx cut the circle g_2 at q and q', and the hyperbola at d. Join dw (or dw') to cut the circle g_1 again at p (or p'). Then cp (or cp') is conjugate to cx for the circle g_1. Let cpp' cut ww' at y. Join g_1y and draw g_2z parallel to it to meet ww' at z, then cz is conjugate to cx for the circle g_2.

12. If in (11) cx cut ww' at x, then points like x and y are harmonically conjugate with respect to w and w', *i.e.* form involution pairs having ww' as the double points. Points like x and z also form involution pairs with no real double points, o being the centre of the involution and $-nw'^2$ the involution constant.

If $x_1, x_2 \ldots, y_1, y_2 \ldots, z_1, z_2, z_3 \ldots$ be corresponding points, then $(z_1z_2z_3 \ldots) = (x_1x_2x_3 \ldots) = (y_1y_2y_3 \ldots)$, also $c(z_1z_2z_3 \ldots) = c(y_1y_2y_3 \ldots)$.

The point pairs y, z form involution pairs with n and the point at infinity on ww' as double points. y and z are equidistant from n. The double lines of the corresponding involution pencil at c are cn and vcv'.

Consideration by Coordinate Geometry.

13. *Areal coordinates.* If cww' be taken as the triangle of reference, taking ww' as $x=0$, cw as $y=0$, cw' as $z=0$, so that $ww'=a$, $cw=cw'=b$, the equation of the circle, centre g_1, is given by

$$b^2x^2 - a^2yz = 0. \qquad \text{(i)}$$

The equation of the hyperbola conjugate to the circle with respect to the secant line $x=0$ is given by

$$b^2x^2 + a^2yz = 0. \qquad \text{(ii)}$$

14. *Cartesian coordinates.* Taking cg_1 as the x-axis and cv', *i.e.* the perpendicular through c to cg_1 as the y-axis, and writing the equation of the circle g_1 as

$$x^2 + y^2 - 2gz + c = 0, \qquad \text{(i)}$$

we get the hyperbola conjugate to this circle with respect to the polar of the origin as

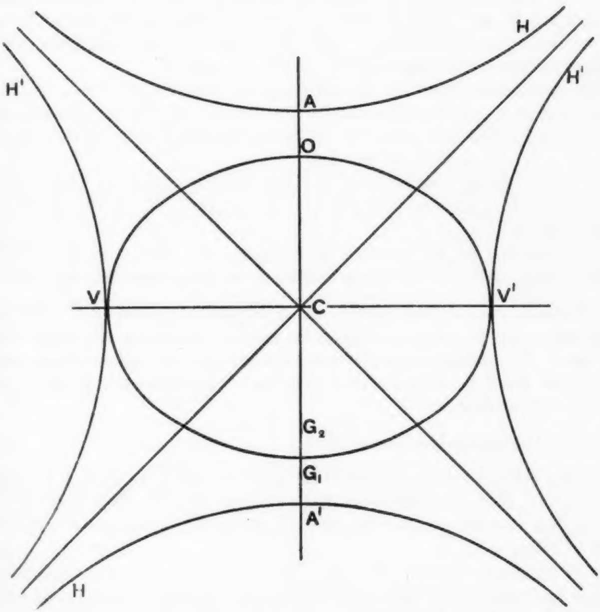
$$\left.\begin{aligned} x^2(2g^2 - c) - cy^2 - 2gcx + c^2 &= 0 \\ \text{or} \quad -c(x^2 + y^2) + 2g^2x^2 - 2gcx + c^2 &= 0 \end{aligned}\right\}. \qquad \text{(ii)}$$

The equation of the circle g_2 is found to be

$$x^2 + y^2 + 2gx - c = 0. \qquad \text{(iii)}$$

15. *Projection.* If the figure be considered to lie in the p-plane and if it be projected conically by a vertex V on to a plane Π, so that ww' is projected to infinity, then the circle g_1 projects into a hyperbola H, circle g_2 into an ellipse E concentric with H. The hyperbola conjugate to circle g_1 with respect to the secant line ww' projects into the conjugate hyperbola H' of H touching the ellipse E.

Using capital letters for the projection, the following relations between H and H' are easily established.



(i) If CP, CD be conjugate semi-diameters of a hyperbola terminated by itself and its conjugate at P and D respectively, then PD is parallel to an asymptote.

(ii) If CP_1, CD_1 and CP_2, CD_2 be two pairs of conjugate semi-diameters, then P_1P_2 and D_1D_2 meet on an asymptote.

(iii) The tangents at P and D meet on an asymptote.

(iv) PD is bisected by an asymptote.

(v) The tangent at P is parallel to CD and the tangent at D parallel to CP.

(vi) CP bisects chords parallel to CD and *vice versa*.

Projecting from the p-plane to the Π-plane by means of a vertex

of projection, such that ww' is the vanishing line in the p-plane ; the circle g_1 projects into a hyperbola H having C, the projection of c as centre ; the hyperbola conjugate to the circle into another hyperbola H' with the same asymptotes, and such that the conjugate lines through C for H are also conjugate for H'.

Of two conjugate diameters, one cuts one hyperbola and the other the other hyperbola. The length of a diameter is the length of it as terminated by either hyperbola.

VV' is a diameter of H' and the circle g_2 projects into an ellipse E touching H' at V and V', centre C, and having asymptotes $C\Omega$ and $C\Omega'$ as conjugate diameters. aca' projects into the diameter ACA' conjugate to VCV' with respect to H, H' and E.

The vanishing line l in the Π-plane is parallel to VV'. G_1, the projection of g_1, is the pole of this line for H. G_2 the projection of g_2 is the pole of this line l for E. O, the projection of o, is the pole of l for H'. G_1, G_2 and O lie on AA'.

We have these results : C is the middle point of OG_1. (For $(cn, og_1) = -1$. Hence $(CN, OG_1) = -1$. But N is the point at infinity on AA'.)

If AA' cuts l at K, then $(CK, G_1G_2) = -1$. For c is the middle point of g_1g_2, and if k be the point at ∞ in g_1g_2, then $(ck, g_1g_2) = -1$.

Definition. If V be a point on a hyperbola, and VV' the diameter through V, and an ellipse be drawn touching the hyperbola at V and V' and having the asymptotes as conjugate lines, then this ellipse shall be called the " INVOLUTORY ELLIPSE " at the point V of the hyperbola.

We get the following theorems :

(1) If a straight line be taken parallel to the diameter VV', then the poles of this straight line with respect to the two hyperbolas H and H', *i.e.* the points G_1 and O, are such that C is the middle point of OG_1.

(2) If CP and CD be two conjugate diameters with reference to the hyperbolas, and if CP cuts the Involutory Ellipse corresponding to any point on either hyperbola at Q and Q', then the line through Q parallel to one asymptote meets that through Q' parallel to the other on CD. (For wq and $w'q'$ meet on the conjugate to qq' to the circle g_1.)

(3) If CP, CD be conjugate semi-diameters of H and H', and if CQ be the diameter conjugate to CD of the Involutory Ellipse at the point V, the pairs of lines like CP, CQ form an involution pencil having CV and CA (conjugate to CV) as double lines.

(For, as we saw, $c(y_1y_2 \dots) = c(z_1z_2 \dots)$ note 12 above.)

(4) If VCV' be the transverse axis of H', then VCA is a right angle, and the Involutory Ellipse at V touches both hyperbolas (for $C(\Omega\Omega', AV) = -1$ and VCA is a right angle. Therefore CV and CA bisect the angles between the asymptotes. Tangents at A and V to H and H' respectively meet on the asymptote $C\Omega$. But $C\Omega$, $C\Omega'$

are conjugate diameters of the ellipse E. Hence they are the equi-conjugate diameters, and the ellipse touches the hyperbola at A and A' also.)

If, moreover, the hyperbolas be rectangular, the ellipse becomes a circle, viz. the Auxiliary Circle.

(5) The Involutory Ellipse at the point $(a\sec\phi,\ b\tan\phi)$ of the hyperbola $\frac{x^2}{a^2}-\frac{y^2}{b^2}-1=0$ is

$$\left(\frac{x^2}{a^2}+\frac{y^2}{b^2}-1\right).ab.(1+\sin^2\phi)=4\sin\phi\,.\,xy-2ab\sin^2\phi$$
$$=2\sin\phi\,(2xy-ab\sin\phi).$$

J.B.F.

1159. THE BEE'S CELL.

These hexagons are closed by a pyramid; the angles of the three sides of a similar pyramid, such as would accomplish the given end with the smallest quantity possible of materials were determined by a mathematician as 109 degrees 26 minutes for the larger, 70 degrees 34 minutes for the smaller. The actual measure is 109 degrees 28 minutes, 70 degrees 32 minutes. Yet this perfect harmony raises the work at the expense of the artist: the bees are not masters of transcendental geometry.—E. Gibbon, *Decline and Fall*, Methuen's edition, VI, p. 27, f.n.

An attempt has recently been made to show that there is no discrepancy between the actual dimensions of the cells and the measures which would require the minimum of material.—Bury's note, *l.c.*

Dec. 6, 1838. . . . He [Brougham] is all day working sums in algebra or extracting cube roots; and while he pretends to be poring over the great book (the cases of the parties) before him, he is in reality absorbed in his own calculations. Nevertheless, he from time to time starts up, and throws in a question, a dictum or a lecture, just as if he had been profoundly attentive.

Dec. 19, 1838. I found the explanation of his calculations at the Council Board in the fact that he was working out some problems for the purpose of proving the form of the structure of honeycombs.—*Greville Diary*, I (1927), p. 530.

He [Maraldi] . . . tells us that the angles of the rhomb arc are 110° and 70° . . . but at the same time he speaks of the angles as being, respectively, 109° 28′ and 70° 32′. Here a singular confusion at once arose, and has been perpetuated in the books. "Unfortunately [as explained by Leslie Ellis] Réaumur chose to look upon this second determination of Maraldi's as being, as well as the first, a direct result of measurement, whereas it is in reality theoretical." . . . It now occurred to Réaumur that . . . the actual solid figure, as determined by Maraldi, might be that which, for a given solid content, gives the minimum of surface. . . . Koenig confirmed his conjecture, the result of his calculations agreeing within two minutes (109° 26′ and 70° 34′) with Maraldi's determination. Maclaurin (*Phil. Trans.* 1743) and Lhuilier, by different methods, . . . were able to shew that the discrepancy of 2′ was due to an error in Koenig's calculation (of $\tan\theta=\sqrt{2}$)—that is to say to the imperfection of his logarithm tables—not (as the books say) "to a mistake on the part of the bee". "Not to a mistake on the part of Maraldi" is, of course, all we are entitled to say.—D'Arcy W. Thompson, *Growth and Form* (1917), p. 329. [Per Prof. H. G. Forder.]

EXPANSIONS BY MEANS OF THE FRACTIONAL CALCULUS.

BY W. FABIAN.

1. WE have shown * how the theory of the Fractional Calculus enables us to expand functions in various forms. In the present paper we shall obtain some further expansions.

A λth integral of $f(z)$ along a simple curve l is defined by *

$$D^{-\lambda}(l_a)f(z)=\frac{D^{\gamma}}{\Gamma(\lambda+\gamma)}\int_a^z(z-t)^{\lambda+\gamma-1}f(t)\,dt,$$

where γ is the least integer greater than or equal to zero such that $R(\lambda)+\gamma>0$; D stands for d/dz, and the integration and differentiation are along l.

2. *Expansions of functions in an infinite series.*

Of the expansions of functions which we have established so far, the most interesting are the following :

I. The *Riemann Series*,† which reduces to a Taylor series for integral values of λ :

Let $f(z)$ be analytic on l. Let a, c and z_0 be three different points on l, taken in this order on this curve. If ‡

$$\lim_{n\to\infty} D^{-\lambda-n}(l_c)f_{-\lambda-n}(z_0)+\lim_{n\to\infty}\frac{1}{\Gamma(\lambda-n)}\int_a^c(z_0-t)^{\lambda-n-1}f_{n-\lambda}(t)dt=0,$$

where the integrations are along l, then, for $z=z_0$,

$$f(z)=\sum_{n=-\infty}^{\infty}\frac{D^{\lambda+n}(l_a)f(c)}{\Gamma(\lambda+n+1)}(z-c)^{\lambda+n}.$$

II. The series §

$$f(z)=\frac{1}{\Gamma(-\lambda)}\sum_{n=0}^{\infty}(-1)^n\frac{f_{\lambda-n}(z)}{n!(n-\lambda)}(z-a)^{n-\lambda},$$

in which $f(z)$ can be expanded under either of the following two hypotheses :

(A) *At a point $z=z_0$, the centre of a circle containing l in its interior, within which $f(z)$ is analytic* ; $R(\lambda)<0$, *and*

$$f(a)=f'(a)=\ \dots\ =f^{(\gamma-2)}(a)=0\ \ if\ \ R(\lambda)\leqslant -1\ ;$$

and the Taylor series for $f_\lambda(z)$ at z_0 converges on l uniformly to $f_\lambda(z)$.

* Fabian, *Phil. Mag.* (7) 20 (1935), 781-9. *Quarterly Journ. of Math.* (1936).

† Fabian, *Phil. Mag.* (7) 20 (1935), 781-9.

‡ $f_{-\lambda-n}(z_0)$ stands for $D^{\lambda+n}(l_a)f(z_0)$, and, generally, $f_\lambda(z$ will be written for $D^{-\lambda}(l_a)f(z)$, when no ambiguity can arise.

§ Fabian, *Quarterly Journ. of Math.* (1936).

(B) *For those values of z for which*

$$\frac{D^{\delta}}{\Gamma(\delta-\lambda)}\int_a^z \left\{(z-t)^{\delta-\lambda-1}\int_z^t f_{\lambda-n}(t)\,dt^n\right\}dt$$

tends to zero, and $(z-a)^{n-\lambda} f_{\lambda-n}(z)$ *remains bounded, when the positive integer n tends to infinity, where all integrations are along l,* λ *is any number, and* δ *a non-negative integer such that* $R(-\lambda)+\delta>0$; $f(z)$ *is analytic on l, and*

$$f(a)=f'(a)=\ \dots\ =f^{(\nu-2)}(a)=0 \quad \textit{if} \quad R(\lambda)\leqslant -1.$$

3. We shall obtain now new types of expansions.

I. *Expression of a function as the sum of an infinite series and another function.*

Theorem 1. *Let* $f(z)$ *be analytic on l. Let a, c and* z_0 *be three different points on l, taken on this curve in this order. If*

$$\lim_{n\to\infty}\frac{1}{\Gamma(\lambda-n)}\int_a^c (z_0-t)^{\lambda-n-1} f_{n-\lambda}(t)\,dt=0,$$

where the integration is along l, and the lower limit of integration for $f_{n-\lambda}(t)$ *is a, then*

$$f(z_0)=\sum_{n=1}^{\infty}\frac{D^{\lambda-n}(l_a)f(c)}{\Gamma(\lambda-n+1)}(z_0-c)^{\lambda-n}+D^{-\lambda}(l_c)\,D^{\lambda}(l_a)f(z_0).$$

Proof.—Let β be such that $0\leqslant R(\beta)<1$, and such that $\lambda+\beta$ is an integer. By a previous theorem,*

$$\begin{aligned} f(z_0) &= D^{\beta}(l_a)\,D^{-\beta}(l_a)f(z_0)\\ &= \frac{D}{\Gamma(1-\beta)}\int_a^c (z_0-t)^{-\beta}D^{-\beta}(l_a)f(t)\,dt + D^{\beta}(l_c)\,D^{-\beta}(l_a)f(z_0)\\ &= \sum_{m=1}^{p}\frac{D^{-\beta-m}(l_a)f(c)}{\Gamma(-\beta-m+1)}(z_0-c)^{-\beta-m}\\ &\quad+\frac{1}{\Gamma(-\beta-p)}\int_a^c (z_0-t)^{-\beta-p-1}D^{-\beta-p}(l_a)f(t)\,dt + D^{\beta}(l_c)\,D^{-\beta}(l_a)f(z_0), \end{aligned}$$

on integrating $\int_a^c (z_0-t)^{-\beta}D^{-\beta}(l_a)f(t)\,dt$ by parts p times. Hence, putting $\beta=-\lambda+q$ and $m=n-q$, we have, under the conditions of the theorem,

$$f(z_0)=\sum_{n=q+1}^{\infty}\frac{D^{\lambda-n}(l_a)f(c)}{\Gamma(\lambda-n+1)}(z_0-c)^{\lambda-n}+D^{-\lambda+q}(l_c)\,D^{\lambda-q}(l_a)f(z_0).$$

The conclusion is obtained for the case $q=0$. If q is positive, the conclusion follows on integrating $D^{-\lambda+q}(l_c)D^{\lambda-q}(l_a)f(z_0)$ by parts q times. If q is negative, the theorem follows on integrating $D^{-\lambda}(l_c)\,D^{\lambda}(l_a)f(z_0)$ by parts $(-q)$ times.

* Fabian, *Phil. Mag.* (7) 20 (1935), 781-9.

II. *Expansions in a double series.*

Theorem 2. *Let $f(z)$ be analytic on l, on which three points a, z_0 and c are taken in this order such that the path of integration for $D^{-\lambda}(l_a)f(z_0)$ lies within the circle $|z-z_0|=|c-z_0|$. If*

$$R(\lambda)\leqslant -1,\ \textit{let}\ f(a)=f'(a)=\ \dots\ =f^{(\gamma-2)}(a)=0.$$

Then, if $\lim\limits_{n\to\infty} D^{\lambda}(l_a)D^{-n}(l_c)D^{n-\lambda}(l_a)f(z_0)=0$,

$$f(z_0)=\frac{1}{\Gamma(-\lambda)}\sum_{n=0}^{\infty}\left\{\sum_{s=0}^{\infty}(-1)^s\frac{D^{n-\lambda}(l_a)f(c)\,.\,(z_0-a)^{s-\lambda}(z_0-c)^{n-s}}{s!(s-\lambda)\Gamma(n-s+1)}\right\}.$$

Proof. $f(z_0)=D^{\lambda}(l_a)D^{-\lambda}(l_a)f(z_0)$ *

$$=\frac{D^{\delta}}{\Gamma(\delta-\lambda)}\int_a^{z_0}(z_0-t)^{\delta-\lambda-1}\left\{\frac{d}{dt}\int_c^t D^{-\lambda}(l_a)f(r)dr\right\}dt$$

(where the integrations and differentiations are along l, and δ is the least integer greater than or equal to zero such that $R(-\lambda)+\delta>0$)

$$=\frac{D^{\delta}}{\Gamma(\delta-\lambda)}\int_a^{z_0}(z_0-t)^{\delta-\lambda-1}\left\{\sum_{m=0}^{n-1}\frac{D^{m-\lambda}(l_a)f(c)}{m!}(t-c)^m\right\}dt$$
$$+D^{\lambda}(l_a)D^{-n}(l_c)D^{n-\lambda}(l_a)f(z_0)$$

(on integrating $\int_c^t D^{-\lambda}(l_a)f(r)dr$ by parts n times)

$$=\frac{D^{\delta}}{\Gamma(\delta-\lambda)}\sum_{m=0}^{n-1}\frac{D^{m-\lambda}(l_a)f(c)}{m!}\int_a^{z_0}(z_0-t)^{\delta-\lambda-1}$$
$$\times\left\{\sum_{s=0}^{\infty}\frac{(-1)^s\Gamma(m+1)}{s!\Gamma(m-s+1)}(z_0-c)^{m-s}(z_0-t)^s\right\}dt$$
$$+D^{\lambda}(l_a)D^{-n}(l_c)D^{n-\lambda}(l_a)f(z_0)$$

$$=\frac{1}{\Gamma(-\lambda)}\sum_{m=0}^{n-1}\sum_{s=0}^{\infty}(-1)^s\frac{D^{m-\lambda}(l_a)f(c)\,.\,(z_0-a)^{s-\lambda}(z_0-c)^{m-s}}{s!(s-\lambda)\Gamma(m-s+1)}$$
$$+D^{\lambda}(l_a)D^{-n}(l_c)D^{n-\lambda}(l_a)f(z_0).$$

The theorem follows immediately.

Theorem 3. *Let $f(z)$ be analytic on l, on which three points a, z_0 and c are taken in this order such that the path of integration for $D^{-\lambda}(l_a)f(z_0)$ lies within the circle $|z-a|=|c-a|$. If*

$$R(\lambda)\leqslant -1,\ \textit{let}\ f(a)=f'(a)=\ \dots f^{(\gamma-2)}(a)=0.$$

Then, if $\lim\limits_{n\to\infty} D^{\lambda}(l_a)D^{-n}(l_c)D^{n-\lambda}(l_a)f(z_0)=0$,

$$f(z_0)=\sum_{n=0}^{\infty}\left\{\sum_{s=0}^{\infty}\frac{D^{n-\lambda}(l_a)f(c)\,.\,(a-c)^{n-s}(z_0-a)^{s-\lambda}}{\Gamma(n-s+1)\Gamma(s-\lambda+1)}\right\}.$$

* Fabian, *Phil. Mag.* (7) 20 (1935), 781-9.

Proof. $$f(z_0) = D^{\lambda}(l_a)D^{-\lambda}(l_a)f(z_0)$$

$$= \frac{D^{\delta}}{\Gamma(\delta-\lambda)}\int_a^{z_0}(z_0-t)^{\delta-\lambda-1}\left\{\frac{d}{dt}\int_c^t D^{-\lambda}(l_a)f(r)\,dr\right\}dt$$

(the integrations and differentiations being along l, and δ being the least integer greater than or equal to zero such that $R(-\lambda)+\delta>0$)

$$= \frac{D^{\delta}}{\Gamma(\delta-\lambda)}\int_a^{z_0}(z_0-t)^{\delta-\lambda-1}\left\{\sum_{m=0}^{n-1}\frac{D^{m-\lambda}(l_a)f(c)}{m!}(t-c)^m\right\}dt$$
$$+ D^{\lambda}(l_a)\,D^{-n}(l_c)\,D^{n-\lambda}(l_a)f(z_0)$$

(on integrating $\int_c^t D^{-\lambda}(l_a)f(r)\,dr$ by parts n times)

$$= \sum_{m=0}^{n-1} D^{m-\lambda}(l_a)f(c)\,.\,\frac{D^{\delta+1}}{\Gamma(\delta-\lambda+1)}\int_a^{z_0}(z_0-t)^{\delta-\lambda}\left\{\sum_{s=0}^{\infty}\frac{(a-c)^{m-s}(t-a)^s}{s!\,\Gamma(m-s+1)}\right\}dt$$
$$+ D^{\lambda}(l_a)\,D^{-n}(l_c)\,D^{n-\lambda}(l_a)f(z_0)$$

$$= \sum_{m=0}^{n-1}\sum_{s=0}^{\infty}\frac{D^{m-\lambda}(l_a)f(c)\,.\,(a-c)^{m-s}(z_0-a)^{s-\lambda}}{\Gamma(m-s+1)\,\Gamma(s-\lambda+1)}$$
$$+ D^{\lambda}(l_a)\,D^{-n}(l_c)\,D^{n-\lambda}(l_a)f(z_0).$$

The conclusion follows.

Theorem 4. *Let $f(z)$ be analytic on l, except possibly at a point c, at which $D^{-\lambda}(l_a)f(z)$, where $R(\lambda)\leqslant -1$, can be expanded in a Puiseux series $\sum_{(\sigma)} A_\sigma(z-c)^\sigma$. Let the points a, z_0 and c on l be such that the path of integration for $D^{-\lambda}(l_a)f(z_0)$ lies within the circle $|z-z_0| = |c-z_0|$. Also, let $f(a) = f'(a) = \ldots = f^{(\gamma-2)}(a) = 0$. Then*

$$f(z_0) = \frac{1}{\Gamma(-\lambda)}\sum_{(\sigma)}\left\{\sum_{s=0}^{\infty}(-1)^s\frac{A_\sigma\Gamma(\sigma+1)(z_0-a)^{s-\lambda}(z_0-c)^{\sigma-s}}{s!\,(s-\lambda)\,\Gamma(\sigma-s+1)}\right\},$$

provided that the Puiseux series for $D^{-\lambda}(l_a)f(z)$ at c converges uniformly to $D^{-\lambda}(l_a)f(z)$ on the path of integration for $D^{-\lambda}(l_a)f(z_0)$.

Proof. $$f(z_0) = D^{\lambda}(l_a)\,D^{-\lambda}(l_a)f(z_0)$$

$$= \frac{1}{\Gamma(-\lambda)}\sum_{(\sigma)}A_\sigma\int_a^{z_0}(z_0-t)^{-\lambda-1}(t-c)^\sigma\,dt$$

$$= \frac{1}{\Gamma(-\lambda)}\sum_{(\sigma)}A_\sigma\int_a^{z_0}(z_0-t)^{-\lambda-1}\left\{\sum_{s=0}^{\infty}\frac{(-1)^s\Gamma(\sigma+1)(z_0-c)^{\sigma-s}(z_0-t)^s}{s!\,\Gamma(\sigma-s+1)}\right\}dt$$

$$= \frac{1}{\Gamma(-\lambda)}\sum_{(\sigma)}\left\{\sum_{s=0}^{\infty}(-1)^s\frac{A_\sigma\Gamma(\sigma+1)(z_0-a)^{s-\lambda}(z_0-c)^{\sigma-s}}{s!\,(s-\lambda)\,\Gamma(\sigma-s+1)}\right\}.$$

Theorem 5. *Let $f(z)$ be analytic on l, except possibly at a point c, at which $D^{-\lambda}(l_a)f(z)$, where $R(\lambda)\leqslant -1$, can be expanded in a Puiseux series $\sum_{(\sigma)} A_\sigma(z-c)^\sigma$. Let the points a, z_0 and c on l be such that the*

path of integration for $D^{-\lambda}(l_a)f(z_0)$ *lies within the circle* $|z-a|=|c-a|$. *Also, let* $f(a)=f'(a)=\ldots=f^{(\nu-2)}(a)=0$. *Then*

$$f(z_0)=\sum_{(\sigma)}\left\{\sum_{s=0}^{\infty}\frac{A_\sigma\Gamma(\sigma+1)(a-c)^{\sigma-s}(z_0-a)^{s-\lambda}}{\Gamma(\sigma-s+1)\Gamma(s-\lambda+1)}\right\},$$

provided that the Puiseux series for $D^{-\lambda}(l_a)f(z)$ *at* c *converges uniformly to* $D^{-\lambda}(l_a)f(z)$ *on the path of integration for* $D^{-\lambda}(l_a)f(z_0)$.

Proof.

$$\begin{aligned} f(z_0) &= D^{\lambda}(l_a)D^{-\lambda}(l_a)f(z_0)\\ &=\frac{1}{\Gamma(-\lambda)}\sum_{(\sigma)}A_\sigma\int_a^{z_0}(z_0-t)^{-\lambda-1}(t-c)^{\sigma}\,dt\\ &=\frac{1}{\Gamma(-\lambda)}\sum_{(\sigma)}A_\sigma\int_a^{z_0}(z_0-t)^{-\lambda-1}\left\{\sum_{s=0}^{\infty}\frac{\Gamma(\sigma+1)(a-c)^{\sigma-s}(t-a)^{s}}{s!\,\Gamma(\sigma-s+1)}\right\}dt\\ &=\sum_{(\sigma)}\left\{\sum_{s=0}^{\infty}\frac{A_\sigma\Gamma(\sigma+1)(a-c)^{\sigma-s}(z_0-a)^{s-\lambda}}{\Gamma(\sigma-s+1)\Gamma(s-\lambda+1)}\right\}. \end{aligned}$$

W. F.

1160. . . . partout des rangées d'arbres parallèles, des bâtisses tirées au cordeau, des constructions plates, de longues lignes froides, et la tristesse lugubre des angles droits. Pas un accident de terrain, pas un caprice d'architecture, pas une folie. C'était un ensemble glacial, régulier, hideux. Rien ne serre le cœur comme la symétrie. C'est que la symétrie, c'est l'ennui, et l'ennui est le fond même du deuil.—Victor Hugo, *Les Misérables*, Livre Quatrième, chap. 2 ; p. 63 of Vol. II in Nelson's edition. [Per Mr. J. W. Stewart.]

1161. From *A Short Introduction to the History of Human Stupidity*, by Walter P. Pitkin.

For mastery of nature rests on mathematics—which in turn rests on logic mainly.

So . . . we must say that the entire human race is stupid with regard to mathematical relations and always has been. . . . Taken as a whole, the human race is mathematically moron.

Even competent mathematicians cannot think through, in imagination, unaided by machines and other external devices, more than three non-cumulative variables in any single problem. What this means in practice will be evident when you observe that most real-life problems involve scores of variables, most of which are non-cumulative.

Nowhere do we behold man's profound mathematical-logical stupidity more lucidly than in the public schools and the ranks of newspaper readers.

What subject in public schools is always regarded as the hardest? In which do pupils fail oftenest? Mathematics, of course.

To state a simple proportion in bald language is to baffle at least seven out of ten readers. And a compound proportion is absolutely unprintable.

We find a third, even more startling proof of the mathematical imbecility of most people. It is the entire history of business. [Per Mr. A. F. Mackenzie.]

1162. There is dignity about 999. Stopping just short of the " cool thou.", it betrays agitation ; being one-third as big again as the Number of the Beast, it has its sinister significance.—*Times*, Leading Article, 4th July, 1937. (Rev. xiii. 18 gives the Beast's number as " Six hundred threescore and six ".) [Per the Right Rev. the Bishop of Kootenay.]

INVARIANTS AND COVARIANTS OF THREE CONICS

By J. Clemow.

This paper is a sequel to a paper entitled "The Harmonic Conics", *Math. Gazette*, Vol. XIX, page 98. How is it that text books on Algebraic Geometry deal with invariants and covariants of two conics yet never so much as hint at the existence of such forms for more than two conics? *

Mutual Invariant of Three Conics.

Let S_1, S_2, S_3 be three independent conics. We can approach the subject of their mutual invariant as Salmon does, by expanding the discriminant of $\lambda_1 S_1 + \lambda_2 S_2 + \lambda_3 S_3 = 0$. This discriminant is

$$\begin{vmatrix} \lambda_1 a_1 + \lambda_2 a_2 + \lambda_3 a_3 & & \\ & \lambda_1 b_1 + \lambda_2 a_2 + \lambda_3 a_3 & \\ & & \lambda_1 c_1 + \lambda_2 c_2 + \lambda_3 c_3 \end{vmatrix}$$

which we expand in the form

$$\theta_{111}\lambda_1^3 + \theta_{112}\lambda_1^2\lambda_2 + \theta_{113}\lambda_1^2\lambda_3 + \theta_{123}\lambda_1\lambda_2\lambda_3 + \text{etc.},$$

where the coefficients θ are polynomials in coefficients of S_1, S_2, S_3 only. In particular θ_{111} is the form previously denoted by Δ, θ_{112} is Θ, θ_{122} is Θ', etc. θ_{123} is a new invariant depending symmetrically on the coefficients of each of S_1, S_2, S_3.

If we try the same procedure with four conics we will get no new forms, for the discriminant is cubic so that at most only three different sets of coefficients can occur in any θ.

Another method of obtaining θ_{123} is to use Cayley's Lemma, that if $I(a_1, b_1, c_1 \ldots)$ is an invariant of a quantic Y_1 then $\Sigma a_2 \dfrac{\partial I}{\partial a_1}$ will be a mutual invariant of Y_1 and Y_2. This lemma is readily extended to covariants. (There is a beautiful account of this theory in Enriques-Chisini "Teoria Geometrica delle Equazioni ecc.", Vol. I, Cap. I.) Thus starting from the mutual invariant Θ, or θ_{112}, of S_1 and S_2 we can form the mutual invariant S_1, S_2 and S_3; in fact

$$\theta_{123} = \Sigma a_3 \frac{\partial \theta_{112}}{\partial a_1} = a_3(b_1c_2 + b_2c_1 - 2f_1f_2) + \ldots . \quad \ldots\ldots\ldots\ldots\ldots(1)$$

It is clear, either from Salmon's method or by use of Cayley's Lemma, that there is just one mutual invariant θ_{123} of S_1, S_2, S_3, and we have two further alternative forms for θ_{123}:

$$\Sigma a_1(b_2c_3 + b_3c_2 - 2f_2f_3), \quad \ldots\ldots\ldots\ldots\ldots(2)$$

$$\Sigma a_2(b_3c_1 + b_1c_3 - 2f_3f_1). \quad \ldots\ldots\ldots\ldots\ldots(3)$$

In the expression Θ for θ_{123} the term $(b_1c_2 + b_2c_1 - 2f_1f_2)$ and similar

* I have since read a good account of invariants in Salmon-Fiedler, ***Analytische Geometrie der Kegelschnitte***, 2ter Teil.

terms are the coefficients of the harmonic envelope Φ_{12} of S_1 and S_2. Therefore the vanishing of θ_{123} means that S_3 is apolar to Φ_{12}. But the forms (1), (2) and (3) are equivalent, hence the theorem : *If three conics S_1, S_2, S_3 are such that S_3 is apolar to the harmonic envelope of S_1 and S_2, then S_2 is apolar to the harmonic envelope of S_3 and S_1, and similarly for S_1.*

The dual form of this theorem is : If Σ_1, Σ_2, Σ_3 are such that Σ_3 is apolar to the harmonic locus of Σ_1 and Σ_2 then Σ_2 is apolar to the harmonic locus of Σ_3 and Σ_1, etc. Now if we take Σ_3 to be the circular points the theorem becomes : *If the F-conic of Σ and Σ' is a rectangular hyperbola then Σ' is apolar to the director circle of Σ and vice versa.*

Covariants of Three and Four Conics.

We denote the F-conic of S_1 and S_2 by $F_{11,22}$, thereby showing that its coefficients are quadratic in those of S_1 and S_2. By Cayley's Lemma we can form a covariant of S_1, S_2, S_3 by operating on $F_{11,22}$ with $\Sigma a_3 \dfrac{\partial}{\partial a_2}$. This covariant we can denote by $F_{11,23}$. Again by operating on this last with $\Sigma a_4 \dfrac{\partial}{\partial a_1}$ we can form $F_{14,23}$, a covariant of the four conics S_1, S_2, S_3, S_4. We have at once relations of the type

$$F_{11,23} \equiv F_{11,32} \equiv F_{23,11} \equiv F_{32,11}, \text{ etc.},$$
$$F_{14,23} \equiv F_{41,23} \equiv F_{41,32} \equiv F_{14,32}, \text{ etc.}$$

but in general $F_{14,23} \not\equiv F_{13,24}$.

We proceed to the geometrical significance of these covariants. We employ the notation of the previous paper, viz. the F-conic of Σ_1 and Σ_2 is denoted by $\{\Sigma_1\Sigma_2\}$, the Φ-conic of S_1 and S_2 by $\{S_1, S_2\}$.

By taking special values, for instance

$$S_1 \equiv (a_1 b_1 c_1 y_1 g_1 h_1)(xyz)^2,$$
$$S_2 \equiv a_2 x^2 + b_2 y^2 + c_2 z^2,$$
$$S_3 \equiv a_3 x^2 + b_3 y^2 + c_3 z^2,$$
$$S_4 \equiv (a_4 b_4 c_4 y_4 g_4 h_4)(xyz)^2,$$

it is easy to verify that the covariant $F_{11,21}$, defined as $\Sigma a_1 \dfrac{\partial F_{11,22}}{\partial a_2}$ is $\{\Sigma_1 \Phi_{12}\}$, and this is known (see paper referred to) to be

$$\theta_{112} S_1 + \theta_{111} S_2.$$

Similarly we can verify the results,

$$F_{11,23} \equiv \{\Sigma_1 \Phi_{23}\},$$
$$F_{12,23} \equiv \{\Phi_{12} \Phi_{23}\},$$
$$F_{12,34} \equiv \{\Phi_{12} \Phi_{34}\}.$$

Consider now the net $\lambda_1 S_1 + \lambda_2 S_2 + \lambda_3 S_3 = 0$. The result of trans-

forming this first to tangentials and then back again to point coordinates must be to multiply the L.H.S. by the discriminant,

$$\Delta = \lambda_1^3\theta_{111} + \lambda_1^2\lambda_2\theta_{112} + \lambda_1^2\lambda_3\theta_{113} + \lambda_1\lambda_2\lambda_3\theta_{123} + \lambda_1\lambda_2^2\theta_{122} + \lambda_1\lambda_3^2\theta_{133} + \lambda_2^3\theta_{222} + \lambda_2^2\lambda_3\theta_{223} + \lambda_2\lambda_3^2\theta_{233} + \lambda_3^3\theta_{333}.$$

Now $\overline{\lambda_1 S_1 + \lambda_2 S_2 + \lambda_3 S_3} = \lambda_1^2\Sigma_1 + \lambda_2^2\Sigma_2 + \lambda_3^2\Sigma_3 + \lambda_2\lambda_3\Phi_{23} + \lambda_3\lambda_1\Phi_{31} + \lambda_1\lambda_2\Phi_{12}.$

Therefore $\overline{\overline{\lambda_1 S_1 + \lambda_2 S_2 + \lambda_3 S_3}} = \lambda_1^4\theta_{111}S_1 + \lambda_2^4\theta_{222}S_2 + \lambda_3^4\theta_{333}S_3$

$$+ \lambda_1^3\lambda_2\{\Sigma_1\Phi_{12}\} + \lambda_1^3\lambda_3\{\Sigma_1\Phi_{13}\} + \lambda_2^3\lambda_1\{\Sigma_2\Phi_{21}\} + \lambda_2^3\lambda_3\{\Sigma_2\Phi_{23}\}$$
$$+ \lambda_3^3\lambda_1\{\Sigma_3\Phi_{31}\} + \lambda_3^3\lambda_2\{\Sigma_3\Phi_{32}\}$$
$$+ \lambda_2^2\lambda_3^2[F_{23} + \bar{\Phi}_{23}] + \lambda_3^2\lambda_1^2[F_{31} + \bar{\Phi}_{31}] + \lambda_1^2\lambda_2^2[F_{12} + \bar{\Phi}_{12}]$$
$$+ \lambda_1^2\lambda_2\lambda_3[\{\Sigma_1\Phi_{23}\} + \{\Phi_{12}\Phi_{13}\}] + \lambda_1\lambda_2^2\lambda_3[\{\Sigma_2\Phi_{13}\} + \{\Phi_{12}\Phi_{23}\}]$$
$$+ \lambda_1\lambda_2\lambda_3^2[\{\Sigma_3\Phi_{12}\} + \{\Phi_{13}, \Phi_{23}\}],$$

(where F_{23} is written for $F_{22,33}$).

We can simplify this by means of the known relations,

$$\{\Sigma_1\Phi_{12}\} \equiv \theta_{112}S_1 + \theta_{111}S_2 \quad \text{.........................(4)}$$
$$\bar{\Phi}_{23} \equiv \theta_{233}S_2 + \theta_{223}S_3 - F_{23}, \text{ etc.}$$

The terms involving F_{23}, F_{31}, F_{12} vanish as they should do; moreover, the coefficients of S_1, S_2, S_3 must be respectively $\lambda_1\Delta$, $\lambda_2\Delta$, $\lambda_3\Delta$. Hence picking out the coefficients of S_1 and comparing with the expression for Δ we have,

$$\{\Sigma_1\Phi_{23}\} + \{\Phi_{12}\Phi_{13}\} \equiv \theta_{123}S_1 + \theta_{113}S_2 + \theta_{112}S_3. \quad \text{.............(5)}$$

We can proceed in a precisely analogous way with the system of four conics $\lambda_1 S_1 + \lambda_2 S_2 + \lambda_3 S_3 + \lambda_4 S_4 = 0$ and obtain,

$$\{\Phi_{12}, \Phi_{34}\} + \{\Phi_{13}, \Phi_{24}\} + \{\Phi_{14}, \Phi_{23}\} \equiv \theta_{234}S_1 + \theta_{341}S_2 + \theta_{412}S_3 + \theta_{123}S_4 \ldots (6)$$

where the L.H.S. can be written as

$$F_{12,34} + F_{13,24} + F_{14,23}.$$

This result contains the previous ones for one, two and three conics or special cases. When we equate indices we must remember Leibniz' Theorem. For instance, putting 1 in place of 2, θ_{123} becomes $2\theta_{113}$, and $\{\Phi_{12}\Phi_{34}\}$ becomes $2\{\Sigma_1\Phi_{34}\}$. Conversely we can obtain the result (5) from (4) by operating with $\Sigma a_3 \dfrac{\partial}{\partial a_1}$, and (6) can be obtained from (5) by operating with $\Sigma a_4 \dfrac{\partial}{\partial a_1}$. Again we can obtain (4) from the relation,

$$\{\Sigma_1, \Sigma_1\} \equiv 2\bar{\Sigma}_1 \equiv 2\theta_{111}S_1$$

for operating on both sides with $\Sigma a_2 \dfrac{\partial}{\partial a_1}$ we have

$$\{\Sigma_1, \Phi_{12}\} + \{\Phi_{12}, \Sigma_1\} \equiv 2\theta_{112}S_1 + 2\theta_{111}S_2,$$

or

$$\{\Sigma_1\Phi_{12}\} \equiv \theta_{112}S_1 + \theta_{111}S_2.$$

The method can clearly be applied to the corresponding tangential forms. We have from the previous paper

$$\{S, F\} \equiv \Theta' \Sigma + \Delta \Sigma'.$$

For S_1 and S_2 this can be written as

$$\{S_1, F_{11,22}\} \equiv \theta_{122}\Sigma_1 + \theta_{111}\Sigma_2,$$

and applying $\Sigma a_3 \dfrac{\partial}{\partial a_1}$ and remembering that Σ is quadratic in coefficients of S, we get,

$$\{S_3, F_{11,22}\} + \{S_1, F_{13,22}\} \equiv \theta_{322}\Sigma_1 + \theta_{122}\Phi_{13} + \theta_{113}\Sigma_2.$$

Applying $\Sigma a_4 \dfrac{\partial}{\partial a_2}$ to this we have,

$$\{S_3, F_{11,24}\} + \{S_1, F_{13,24}\} \equiv \theta_{234}\Sigma_1 + \theta_{124}\Phi_{13} + \theta_{113}\Phi_{24},$$

where, as above,

$$F_{ab,cd} \equiv \{\Phi_{ab}, \Phi_{cd}\}.$$

The theory might be extended to covariants of the form $\{F_{ab,cd}, F_{xy,zu}\}$.

J. C.

1163. I was not devoid of brains, and if I had been, well, any second-rater can do mathematics in its lower branches if he applies himself, for it is independent alike of taste, imagination or humour. My own brain, it is true, has always been obstinately impervious to the attractions of the binomial theorem, even the minor blandishments of recurring decimals and simple equations have left me cold. That no doubt may prejudice my view; yet I cannot but think that in the next generation mathematics will rank among the things that are "simply not done" by cultivated people: we shall by that time have invented such perfect machines for doing it instead.—The Hon. D. T. J. Alpers, late Judge of the Supreme Court of New Zealand, *Cheerful Yesterdays*, 1928 (John Murray). [Per Mr. L. R. Pears.]

1164. The starting and stopping powers of the new trains are far greater than that of the present type. They can pick up at the rate of two miles a second and can brake at three miles a second. The braking enables a train to be pulled up in its own length from a speed of 40 miles an hour.—*West Middlesex Gazette*, October 9, 1937. [Per Mr. F. Ayres.]

1165. "You see, it's the size of the thing which discourages me so. Have you noticed that about murder? It goes by compound interest. Two are twice as bad as one, and three are three times as bad as two."—Margery Allingham, *Dancers in Mourning*. [Per Mr. J. E. Tarver.]

1166. The same exactness must not be expected in all departments of philosophy alike, any more than in all the products of arts and crafts. . . . It is equally unreasonable to accept merely probable conclusions from a mathematician and to demand strict demonstration from an orator.—Aristotle, *Nicomachean Ethics*, I. iii. 1. [Per Mr. A. F. Mackenzie.]

1167. Saying attributed to Florence Nightingale in a broadcast by Rosalind Vaughan Nash on 4th July, 1937: "I don't say that you can prove God like a proposition in Euclid." [Per Mr. W. J. Langford.]

THE PILLORY.

Oxford and Cambridge Joint Board Higher Certificate, 1933.

STATICS AND DYNAMICS (Group IV).

"7. An engine of horse-power H and weight W tons pulls a train up an incline of 1 in 80 against a resistance of R lb. per ton. Find the acceleration of the train in feet per second when the speed of the train is v miles per hour."

Oxford and Cambridge Joint Board School Certificate, 1937.

ELEMENTARY MATHEMATICS I.

"6. Prove that any two sides of a triangle are together greater than the third side."

This theorem is not included in the list given in the regulations, and the examiners do not seem to be aware that it is one of those which are no longer commonly taught. E. H. LOCKWOOD.

Oxford and Cambridge Schools Examination Board Higher Certificate, 1937.

STATICS AND DYNAMICS (Group III, Paper 4).

"9. Two particles of masses m_1, m_2 are connected by an inextensible string. They lie one on each face of a fixed wedge, and the string passes over a fixed smooth pulley at the top of the wedge. The faces of the wedge make angles α, β respectively with the vertical, and the coefficients of friction at the respective faces are μ_1, μ_2. Assuming that the particle of mass m_1 moves down its plane, show that the acceleration of each particle is

$$\{m_1(\cos\alpha - \mu\sin\alpha) - m_2(\cos\beta + \mu_2\sin\beta)\}/m_1 + m_2.$$

Deduce that, if the system is originally at rest, it will remain so if

$$\frac{\cos\beta - \mu_2\sin\beta}{\cos\alpha + \mu_1\sin\alpha} < \frac{m_1}{m_2} < \frac{\cos\beta + \mu_2\sin\beta}{\cos\alpha - \mu_1\sin\alpha}."$$

The value of the acceleration given has g omitted.

The second result needs considerable modification. If the assumption is made that $\cot\beta > \mu_2$ and $\cot\alpha > \mu_1$, the result follows. As the question is set, without this assumption being indicated in the question, it is a definite encouragement to mathematical students to be sloppy and careless in their handling of inequalities. Moreover, the result implies that if $\cot\alpha < u_1$ and $\cot\beta < u_2$, then the system remains at rest if

a negative quantity < a positive quantity < a negative quantity,

whereas the particles would remain at rest if placed on the planes unconnected by the string. The question could easily be improved by giving the restrictions $\cot\alpha < \mu_1$, $\cot\beta < \mu_2$, and then asking what happens if $\cot\alpha \geqslant \mu_1$, $\cot\beta \geqslant \mu_2$.

CORRESPONDENCE.

To the Editor of the *Mathematical Gazette*.

Dear Sir,—I am at a loss to understand the reviews of *Graphs and Statistics* and *Descriptive Mathematics* which have been given such generous space on pp. 246-8 of *The Mathematical Gazette*. One is accustomed to think of *Gazette* reviews as beyond all incisive and fair. Of the wish to be fair the reviewer gives plenty of evidence; but apparently the purpose of the books is too unfamiliar to be readily apprehended, and I am contrite for the obscurities due to me. Inaccuracies or omissions in the reviews, however, suggest some further explanation: I shall instance only

(1) " ease " should replace " care " in the second last line of p. 246;

(2) repeated use of " bewildering " might have been balanced by the fact that Fig. 6 in *D.M.* is entitled " Simplification of Fig. 5, which was taken from *The Journal of Biological Chemistry* ". Fig. 5, spite of its complexity, has been reproduced in several textbooks. It was in fact one cause that led to my realizing the need for a kind of training not obtained from the ordinary mathematics;

(3) the reference to " a long-lost treasure " (p. 247, last line) is absurd in view of the remark in *D.M.* p. iii, " Were the book written to make an immediate popular appeal in educational circles, . . . ";

(4) there seems to be no need to " *feel* that there must be much supplementing of the text " (p. 248, l. 7) in view of " the responsibility is here put on the student himself of finding examples for practice " (*D.M.* p. iii) and " the exposition in places has been made somewhat concise . . . subjects . . . such as are fully dealt with in the usual textbooks, and the teacher can supplement the presentation here as circumstances may dictate " (*D.M.* p. iv); and immediately after

(5) " this book probably comprises more than can be studied effectively in one year " conflicts with " all " in the last sentence of the review.

However, what is of importance here is to note the danger of the point of view indicated in the concept " non-mathematical student " in this last statement being stereotyped. Names like A. V. Hill and R. A. Fisher suggest the increasing importance of a type of scholar, mathematicians who yet would not wish themselves called mathematicians; and, moving to a lower level, it need scarcely be argued that the sooner the schools can supply the ranks of biologists and economists with students who find it possible to read a quantitative statement other than as " etc,", the better it will be for our soundness and peace of mind. More conventionally, these two books have been judged from the familiar (but in this case, one hopes, premature!) standpoint as ordinary textbooks to meet the generally satisfactory aims we now follow; and what seem to be their really adventurous features have not been noted or tested. My hopes seem lost of finding through the pages of the *Gazette* some who can

help in the making of a road through the tangle of more or less effective applications of elementary mathematics in present-day science, so that students of the near future may be enabled to get the more directly to the essentials in the bodies of knowledge which are in process of formation. This can be done more effectively in the mathematics class than in such special courses of statistics as are given in, say, *The Lancet*, *The Textile Journal*, agricultural publications, etc.—courses which are a sign of a growing mathematical need.

"Adventurous" aspects of the books which need to be examined critically may be listed in the space available here :

(1) The proper appreciation of such laws as Pareto's (*G.* & *S.* 9. 41).
(2) *G.* & *S.* 9. 46 may usefully be simplified in view of the increasing importance of insurance of many kinds.
(3) Are there other examples of the use of generalised triangles of reference (*G.* & *S.* 9. 52)?
(4) Can *D.M.* viii, ix be standardised for India?
(5) Should the tabulation of *calculations* be more systematised? *D.M.* 136.
(6) Can the device on p. 23 of *D.M.* be adopted in schools?
(7) How far does facility in calculation help appreciation of concepts in pure mathematics? Cf. *D.M.* 10, Ex. 4, 64 ff. Also Fig. 9.
(8) What can be taught about the detection of periodicities in time series? Cf. *D.M.* 3. 3.
(9) How can ideas of probability be most effectively presented?
(10) Tabulations of facts so as to facilitate putting them in proper perspective. *D.M.* 131-3.

NOTE : nomograms, we feel, present now no special difficulties.

In all this I am not unappreciative of the encouraging statements made in these reviews.—Yours truly,

JOHN MACLEAN.

Wilson College, Bombay, 7.

1168. That queer quantity "infinity" is the very mischief, and no rational physicist should have anything to do with it. Perhaps that is why Mathematicians represent it by a sign like a love-knot.—Sir Arthur Eddington, *New Pathways in Science*, p. 217. [Per Mr. T. S. Venkatraman.]

1169. Cultivation of sunflowers in Germany has now been organised by the Nazi Welfare Association, and seeds have been distributed. From 10 cwt. of seed it is calculated that 150 cwt. of edible oil and 600 cwt. of oil cakes for fodder can be produced, thus helping in the country's aim to attain economic self-sufficiency.—Exchange. *Evening Standard*, July 1937. [Per Prof. L. M. Milne-Thomson.]

1170. Astronomy was an exact though a mystic science. There were no discoveries to be made, only laws to be observed in the correct casting of a horoscope.—F. Tennyson Jesse, *Act of God*. [Per Mr. W. A. Garstin.]

MATHEMATICAL NOTES.

1256. *On the converse of a theorem in elementary geometry.*

§ 1. The theorem in question reads as follows :

If the internal bisector of an angle A of a triangle ABC cuts BC in D, then $AB \cdot AC = AD^2 + BD \cdot DC$.

The converse under consideration is :

If a point D be taken on the base BC of a triangle ABC so that

$$AB \cdot AC = AD^2 + BD \cdot DC, \quad \text{..................(1.1)}$$

is it true that AD is the internal bisector of A ?

Now it is easy to see that (1) imposes a linear condition on the coordinates of the variable point D on BC. Thus, if we take the foot P of the perpendicular from A on BC as the origin and write $PB=\beta$, $PC=\gamma$, $PD=x$ (with due regard to signs in each case), $BD \cdot DC = (\beta - x)(x-\gamma)$ while $AD^2 = p^2 + x^2$, p being the altitude AP. Hence (1.1) gives

$$AB \cdot AC = (\beta - x)(x-\gamma) + p^2 + x^2, \quad \text{...............(1.2)}$$

which is a linear equation for determining x. There is always a point D where the internal bisector of A cuts BC and which hence satisfies (1.1), while (1.2) shows there is only one point D which can fulfil (1.1). This suggests the conclusion that the converse is true.

§ 2. The following line of argument shows, however, that matters are not quite so simple and that the conclusion would be incorrect.

Let AD meet the circumcircle in E. Then from the similar triangles ABD and CED we have $EC/AB = DE/BD$, and from the triangles ADC and BDE, $EB/AC = DE/DC$. Hence in the triangle BEC we have

$$EB \cdot EC = AB \cdot AC \cdot DE^2/BD \cdot DC$$

$$= (BD \cdot DC + DA^2)DE^2/BD \cdot DC \text{ since } AD \text{ is the bisector of the angle } A;$$

$$= DE^2 + BD \cdot DC \text{ since } BD \cdot DC = AD \cdot DE. \quad \text{......(2.1)}$$

If the converse were true, we would have from (2.1) that ED is the internal bisector of the angle BEC ; in other words, that $AB=AC$ and the arbitrary triangle ABC we took should be isosceles !

§ 3. The fallacy arises from our assuming that a linear equation has only one root ! It may have one, or should vanish identically. If it has only one root, the corresponding point D is on the internal bisector of A. The case when (1.2) is satisfied by all values of x corresponds to

$$\beta + \gamma = 0 ; \quad p^2 - \beta\gamma = AB \cdot AC. \quad \text{..................(3.1)}$$

The first condition implies that

$$AB = (p^2 + \beta^2)^{\frac{1}{2}} \quad \text{and} \quad AC = (p^2 + \gamma^2)^{\frac{1}{2}}$$

are equal, that is, that the triangle is isosceles, while the second does not impose any fresh condition at all. It is easily verified directly that (1.1) fails to determine D uniquely on BC in the case of an isosceles triangle and that it is an identity satisfied by all points D on BC.

It may be noted that the fallacy in § 2 arose by applying the converse to the isosceles triangle BEC.

Hence the converse (1.1) is true if amended into either of the following equivalent forms :

If there exists *a unique point* D on the base BC of a triangle such that $AB \,.\, AC = AD^2 + BD \,.\, DC$, then AD is the internal bisector of the angle A. ....(3.2)

If a point D be taken on the base BC of a triangle ABC *for which* $AB \neq AC$, such that $AB \,.\, AC = AD^2 + BD \,.\, DC$, then AD is the internal bisector of the angle A... . ...(3.2)

A. Narasinga Rao.

1257. *The power-series for sin x and cos x.*

Starting with these series, the following is a very simple way of finding their values. We assume that a power-series can be differentiated term by term.

Denote the two series by $s(x)$ and $c(x)$ respectively. We have at once

$$s'(x) = c(x), \quad c'(x) = -s(x).$$

Accordingly, if

$$u(x) = \sin x - s(x), \quad v(x) = \cos x - c(x),$$

we have

$$u'(x) = v(x), \quad v'(x) = -u(x),$$

$$uu' + vv' = 0, \quad u^2 + v^2 = \text{const.};$$

and putting $x = 0$, we find that the constant is zero. Hence for real values of x, u and v are both zero.

For complex values of x, no proof is needed, since the series constitute the definitions of the sine and cosine. M. F. Egan.

1258. *A suggestion.*

When dealing with the theorems concerning two straight lines whose intersection is inaccessible and which have a transversal, one uses the adjectives " corresponding ", " alternate " for certain pairs of angles, and for another pair the lengthy expression " two interior angles on the same side of the transversal ".

For this expression would not the one word " collateral " be suitable ? The word " alternate " is limited to mean two interior angles on opposite sides.

In like manner " collateral " might mean two interior angles on the same side. H. Orfeur.

1259. *Why all this fuss?*

Dear Mr. ——.

We, your pupils, all think you are too pernickety in making us get everything just so in Algebra. The other day when we were doing about speeds I put $t=s/d$ and you got quite excited and said it *must* be $t=d/s$. But *we all* think it would come to about the same thing in the end. You always say " try it with numbers ". What was that problem you gave us the other day ?

" A man walks $4x$ miles uphill at $3\frac{1}{2}$ miles an hour and $3x$ miles downhill at $4\frac{2}{3}$ miles an hour ; this takes five minutes longer than coming back $3x$ miles uphill at $3\frac{1}{2}$ miles an hour and $4x$ miles downhill at $4\frac{2}{3}$ miles an hour ; find x."

You made it

$$\frac{4x}{3\frac{1}{2}}+\frac{3x}{4\frac{2}{3}}-\left(\frac{3x}{3\frac{1}{2}}+\frac{4x}{4\frac{2}{3}}\right)=\frac{1}{12},$$

$$\frac{8x}{7}+\frac{9x}{14}-\frac{6x}{7}-\frac{6x}{7}=\frac{1}{12},$$

$$\frac{x}{14}=\frac{1}{12}, \text{ so that } x=\frac{7}{6}.$$

Try it the other way :

$$\frac{3\frac{1}{2}}{4x}+\frac{4\frac{2}{3}}{3x}-\left(\frac{3\frac{1}{2}}{3x}+\frac{4\frac{2}{3}}{4x}\right)=\frac{1}{12},$$

$$\frac{7}{8x}+\frac{14}{9x}-\frac{7}{6x}-\frac{7}{6x}=\frac{1}{12},$$

$$\frac{63+112-84-84}{72x}=\frac{1}{12},$$

$$\frac{7}{72x}=\frac{1}{12}, \text{ so that } x=\frac{7}{6}.$$

You see, it comes to the same thing in the end !

So why all this fuss ?

Yours indignantly,

A Schoolboy,

per pro C. O. TUCKEY.

1260. *The factors of* 11 . . . 11, *etc.*

In the course of an interesting article which appeared in the *Gazette* (October, 1935) on the " Factorisation of Large Integers " Mr. C. G. Paradine selected the number $(10^{17}-1)/9$ for attack by his methods. Those who like to collect odd results for the benefit of the many boys who enjoy a mild bout of " furor arithmeticus " may be interested in the following table of the prime factors of numbers all of whose digits are " ones ".

$$
\begin{aligned}
11,111 &= 41 \,.\, 271.\\
111,111 &= 3 \,.\, 7 \,.\, 11 \,.\, 13 \,.\, 37.\\
1,111,111 &= 239 \,.\, 4649.\\
11,111,111 &= 11 \,.\, 73 \,.\, 101 \,.\, 137.\\
111,111,111 &= 3^2 \,.\, 37 \,.\, 333667.\\
1,111,111,111 &= 11 \,.\, 41 \,.\, 271 \,.\, 9091.\\
11,111,111,111 &= 21649 \,.\, 513239.\\
111,111,111,111 &= 3 \,.\, 7 \,.\, 11 \,.\, 13 \,.\, 37 \,.\, 101 \,.\, 9901.\\
1,111,111,111,111 &= 53 \,.\, 79 \,.\, 265371653.\\
11,111,111,111,111 &= 11 \,.\, 239 \,.\, 4649 \,.\, 909091.\\
111,111,111,111,111 &= 3 \,.\, 31 \,.\, 37 \,.\, 41 \,.\, 271 \,.\, 2906161.\\
1,111,111,111,111,111 &= 11 \,.\, 17 \,.\, 73 \,.\, 101 \,.\, 137 \,.\, 5882353.\\
11,111,111,111,111,111 &= 2071723 \,.\, 5363222357.\\
111,111,111,111,111,111 &= 3^2.7.11.13.19.37.52579.333667.\\
1,111,111,111,111,111,111 &= \text{a prime}.\\
11,111,111,111,111,111,111 &= 11.41.101.271.3541.9091.27961.\\
111,111,111,111,111,111,111 &= 3.37.43.239.1933.4649.10838689.
\end{aligned}
$$

The factors of $10^n+1 \equiv \dfrac{10^{2n}-1}{10^n-1}$ can be deduced from the above table as far as $n=10$. A few further values are added for reference :

$$
\begin{aligned}
&10^{11}+1 = 11^2 \,.\, 23 \,.\, 4093 \,.\, 8779.\\
&10^{12}+1 = 73 \,.\, 137 \,.\, 99990001.\\
&10^{13}+1 = 11 \,.\, 859 \,.\, 1058313049.\\
&10^{14}+1 = 29 \,.\, 101 \,.\, 281 \,.\, 121499449.\\
&10^{15}+1 = 7 \,.\, 11 \,.\, 13 \,.\, 211 \,.\, 241 \,.\, 2161 \,.\, 9091.\\
&10^{16}+1 = 353 \,.\, 449 \,.\, 641 \,.\, 1409 \,.\, 69857.\\
&10^{17}+1 = 11 \,.\, 103 \,.\, 4013 \,.\, 21993833369.\\
&10^{18}+1 = 101 \,.\, 9901 \,.\, 999999000001.\\
&10^{19}+1 \text{ and } (10^{23}-1)/9 \text{ remain to be factorised.}
\end{aligned}
$$

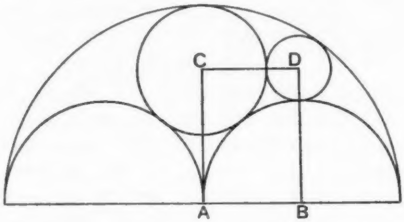
The following table shows the smallest prime p_n whose reciprocal expressed as a decimal, has a period of n figures. The connection with the factors of $(10^n-1)/9$ is obvious.

n	p_n	n	p_n	n	p_n
3	37	10	9091	17	2071723
4	101	11	21649	18	19
5	41	12	9901	19	$(10^{19}-1)/9$
6	7	13	53	20	3541
7	239	14	909091	21	43
8	73	15	31	22	23
9	333667	16	5882353	23	?

A. P. ROLLETT.

1261. *A curious rectangle.*

The circles α, β, γ, δ have centres A, B, C, D and radii a, $\frac{1}{2}a$, c, d. The original problem, set to a lower fifth form, was to calculate



c. This was easily found to be $\frac{1}{3}a$. One boy then suggested calculating d, the radius of a circle δ touching α, β, γ, and quickly produced the correct value $\frac{1}{6}a$. His working proved to be based on the assumption that $ABDC$ was a rectangle, suggested by a carefully drawn figure. This figure was subsequently posted, and solutions invited. A science specialist produced a proof in which D appeared as an intersection of two ellipses, foci (A, B) and (A, C), and a mathematician did it by inversion. But no "fifth form" proof was forthcoming. Perhaps the Junior Mathematical Association could help. A. P. Rollett.

1262. *Simple Methods for* S_1, S_2, S_3 $(S_p = \sum_1^n r^p)$.

I. Consideration of the oblique rows of squares on a chess-board suggests the identity:

$$n^2 = 1 + 2 + 3 + \ldots + (n-1) + n + (n-1) + \ldots + 2 + 1 \ldots\ldots. \quad (1)$$

Adding n to each side

$$n^2 + n = 2S_1 \quad \text{or} \quad S_1 = \tfrac{1}{2}(n^2 + n).$$

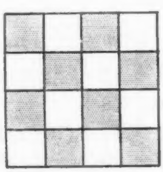


Fig. 1.

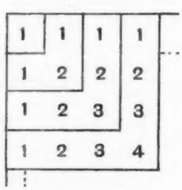


Fig. 2.

II. The sum of the numbers in this array (Fig. 2) is S_2, since the sum in the rth "gnomon" is r^2.

But the sum in the rth row is

$$(1 + 2 + \ldots + r) + (n - r)r = \tfrac{1}{2}r^2 + \tfrac{1}{2}r + nr - {}^2 = n + \tfrac{1}{2})r - \tfrac{1}{2}r^2.$$

Thus adding the rows,

$$S_2 = (n + \tfrac{1}{2})S_1 - \tfrac{1}{2}S_2,$$

or

$$S_2 = \frac{2n+1}{3} \,.\, S_1.$$

III. The sum of the numbers in this array (Fig. 3) is S_3, since the sum in the rth "gnomon" is

$$r + 2r + 3r + \ldots + (r-1)r + r^2 + \ldots + 2r + r = r^3 \text{ from (1).}$$

But in the rth row is rS_1.

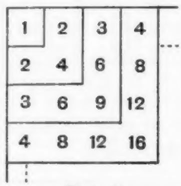


FIG. 3.

Thus the sum by rows is S_1^2. Hence $S_3 = S_1^2$.

IV. To show diagrammatically the relation $3S_2 = (2n+1)S_1$.

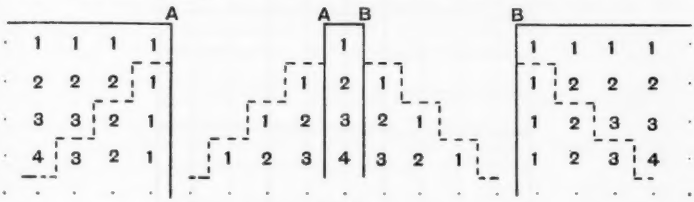


FIG. 4.

The sum of the numbers in each of the three arrays is S_2, by considering the "gnomons" of the squares and the rows of the central figure. Now slide the squares over the central figure until the dotted lines coincide.

The result is a rectangular array whose sum is $(2n+1)S_1$.

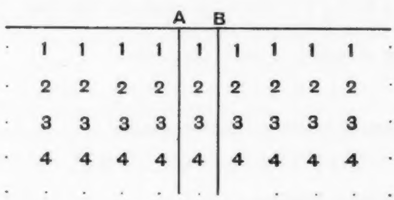


FIG. 5.

A. P. R.

1263. *To sum the cubes of the natural numbers by the use of gnomons.*

Lemma. In any square of cells the addition of the number of cells taken by diagonals is $1+2+3+\ldots(n-1)+n+(n-1)+\ldots+3+2+1$, and this is equal to n^2.

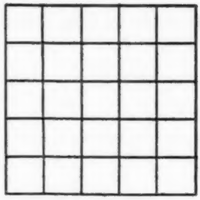


FIG. 1.

Now consider a square of cells arranged like the multiplication table in *Mathematics for the Million.*

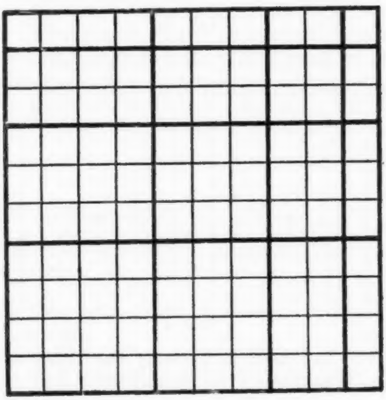


FIG. 2.

The top left-hand cell counts 1. The gnomon of width 2 units contains $2.1+2.2+2.1$ cells (starting at the top, going down to the square (2.2) and then to the left).

The gnomon of width 3 units contains

$$3.1+3.2+3.3+3.2+3.1 \text{ cells};$$

and the gnomon of width n units contains

$$n(1+2+3+\ldots+n+\ldots+3+2+1)$$

which by the above Lemma

$$=n.n^2=n^3.$$

The complete square then contains

$$1+2^3+3^3+\dots+n^3$$

cells ; but the edge is

$$1+2+3+\dots+n$$

units long.

Hence $$\Sigma n^3=(\Sigma n)^2.$$

Or, alternatively :

Suppose Fig. 2 represents a layer of small cubes. Each gnomon can be built up into a solid cube. Thus: take the bottom right-hand square as the base, on it place the bottom strip to the left of it and the top strip above it ; together they form an equal layer ; the strip from the bottom and the strip from the right-hand side next to these form another equal layer, and so on. And a cube of n^3 small cubes is formed. F. C. B.

1264. *On Note* 1231.

The point raised by Mr. Tuckey involves consideration of the following :

(i) The cumulative effect of the unknown $(n+1)$th figures when n-figure tables are used, especially where powers are concerned.

(ii) The extent to which proportional interpolation (which, of course, is used to construct the difference columns) may be relied on in various parts of the tables, for example in the early part of the table of logarithms of numbers.

(iii) The uncertainty which may be introduced when a reading from one table is used in another ; and, of course,

(iv) The well-recognised fact that n-figure accuracy must not be expected from working with n-figure data.

In the case in point, (iii) is the villain of the piece. In using the triangle $1, \sqrt{7}, 2\sqrt{2}$, $\sin^{-1} 1/2\sqrt{2}$ is relatively small and the differences in its neighbourhood large as compared with $\sin^{-1}\sqrt{7}/2\sqrt{2}$; 4-figure tables for logarithmic sines in the 20° line give a difference of 0.0010 for 3′, whereas in the 70° line the difference is 0.0001 for 3′. Thus an error inherent in the first stage is greatly diminished later. On the other hand, in using the triangle 7, 24, 25, $\sin^{-1} 0{\cdot}96$ is relatively large and the differences in its neighbourhood small as compared with $\sin^{-1} 0{\cdot}28$. Thus in the 73° line of the logarithmic sines, the difference for 3′ (more or less) is 0·0001 whereas in the 16° line it is 0·0013 for 3′. Any error, then, inherent in the first stage is seriously increased later.

If, as seems likely from the context of the note, log 0·96 is obtained by using 0·3010 for log 2 and 0·4771 for log 3, consideration (i) takes a hand in the game. For this would give 0·9821 for log 9·6 instead of 0·98227. . . .

Finally, the 7-figure tables produce a satisfactory value of log 7 with the use of the triangle 7, 24, 25, if, instead of reading the value

of the first angle from its sine and reading the sine of the complementary angle, interpolation by proportional parts is used. And here consideration (ii) must be borne in mind for the differences for 1′ in the logarithmic sines in the neighbourhood of sin 16° are not appreciably constant, that is, proportional interpolation must not be relied on to give the seventh figure correct, with the usual reservation. At the same time, since the second differences are about 0·0000004, it will be seen that in this case the error due to the use of interpolation will be less than 0·0000002.

The following tabulation is obtained:

angle	log sine	log cosine
73° 44′	$\bar{1}$·9822569	$\bar{1}$·4473259
$\sin^{-1} 0{\cdot}96$	$\bar{1}$·9822712	$\bar{1}{\cdot}4473259 - h$
73° 44′	$\bar{1}$·9822938	$\bar{1}$·4468927

Proportional differences give

$$\frac{0{\cdot}0000143}{0{\cdot}0000369}=\frac{h}{0{\cdot}0004332}$$

and $h=0{\cdot}0001679$, giving 0·8450980 for log 7.

But this beautifully correct result is too flattering to the working; the numbers 143 and 369 used to obtain h are only 3-figure numbers (not necessarily correct in the third figure); consequently the third figure of 0·0001679 and with it the sixth figure of the value obtained for log 7 should be regarded with distrust. Their accuracy is accidental.

Mr. Tuckey's new question offers, as he suggests, something novel and interesting to occupy an hour's work, but it also offers an opportunity for driving home the invaluable lesson that caution must be observed in assuming any particular degree of accuracy in the results obtained by using tables. F. C. Boon.

1265. *Triangles with integral sides and area.*

The following may be of interest:

(i) If one of the sides is 3, the possible values for the other two sides are included in the general formulae,

$$a_n=\tfrac{1}{2}(3\cosh n\theta+1),$$

$$b_n=\tfrac{1}{2}(3\cosh n\theta-1),$$

and

$$\text{area}=\tfrac{3}{8}\{\cosh(n+1)\theta-\cosh(n-1)\theta\}$$

$$=\tfrac{1}{4}(a_{n+1}-a_{n-1})=\tfrac{1}{4}(b_{n+1}-b_{n-1}),$$

where $\cosh\theta=3$.

(ii) If one of the sides is 4,

$$a_n=2\cosh n\theta+1,$$

$$b_n=2\cosh n\theta-1,$$

and
$$\text{area} = \{\cosh(n+1)\theta - \cosh(n-1)\theta\}$$
$$= \tfrac{1}{2}(a_{n+1} - a_{n-1}) = \tfrac{1}{2}(b_{n+1} - b_{n-1}),$$
where $\cosh\theta = 2$.

(iii) If one of the sides is 5,
$$a_n = \tfrac{1}{2}(5\cosh n\theta + 1),$$
$$bn = \tfrac{1}{2}(5\cosh n\theta - 1),$$
and
$$\text{area} = \tfrac{5}{8}\{\cosh(n+1)\theta - \cosh(n-1)\theta\}$$
$$= \tfrac{1}{4}(a_{n+1} - a_{n-1}) = \tfrac{1}{4}(b_{n+1} - b_{n-1}),$$
where $\cosh\theta = 5$,

or
$$a_n = \tfrac{1}{2}\{5\cosh(n\theta \pm \phi) + 1\},$$
$$b_n = \tfrac{1}{2}\{5\cosh(n\theta \pm \phi) - 1\},$$
and
$$\text{area} = \tfrac{1}{4}(a_{n+1} - a_{n-1}) = \tfrac{1}{4}(b_{n+1} - b_{n-1}\},$$
where $\cosh\theta = 5$, $\cosh\phi = 7/5$.

(iv) If one of the sides is 6,
$$a_n = 3\cosh n\theta + 2,$$
$$b_n = 3\cosh n\theta - 2,$$
and
$$\text{area} = \tfrac{3}{8}\{\cosh(n+1)\theta - \cosh(n-1)\theta\}$$
$$= \tfrac{1}{8}(a_{n+1} - a_{n-1}) = \tfrac{1}{8}(b_{n+1} - b_{n-1}),$$
where $\cosh\theta = 9$.

Similar results can be obtained for any other given side, but as the value for this side increases we get more and more alternative formulae for the other two sides.

Numerical examples of (iii).

n	0		1			2			3		
$\cosh n\theta$	1		5			49			485		
$\cosh(n\theta+\phi)$	7/5		59/5			583/5			5771/5		
$\cosh(n\theta-\phi)$	7/5		11/5			103/5			1019/5		
a_n	3	4	13	30	6	123	292	52	1213	2886	510
b_n	2	3	12	29	5	122	291	51	1212	2885	509
Area	0	6	30	72	12	300	714	126	2970	7068	1248

D. F. FERGUSON.

1266. *Note on the three-cusped hypocycloid.*

The tangential equation of the three-cusped hypocycloid in homogeneous coordinates is

$$\begin{aligned} &a\mu\nu(a\lambda - b\mu\cos C - c\nu\cos B)\\ &+b\nu\lambda(b\mu - c\nu\cos A - a\lambda\cos C)\\ &+c\lambda\mu(c\nu - a\lambda\cos B - b\mu\cos A) = 0, \end{aligned} \quad \text{.................(i)}$$

because this is satisfied by the following values :

$$\left.\begin{aligned} \lambda &= 2R\cos\sigma_1\sin\sigma_2\sin\sigma_3,\\ \mu &= 2R\cos\sigma_2\sin\sigma_3\sin\sigma_1,\\ \nu &= 2R\cos\sigma_3\sin\sigma_1\sin\sigma_2, \end{aligned}\right\} \text{.........................(ii)}$$

where σ_1, σ_2, σ_3 are the angles of the Simson line with the sides of the triangle of reference, whose values are defined by the following equations :

$$\left.\begin{aligned} 2s\cos\sigma_1 &= a\lambda - b\mu\cos C - c\nu\cos B,\\ 2s\cos\sigma_2 &= b\mu - c\nu\cos A - a\lambda\cos C,\\ 2s\cos\sigma_3 &= c\nu - a\lambda\cos B - b\mu\cos A, \end{aligned}\right\} \text{...............(iii)}$$

and λ, μ, ν are the lengths of the perpendiculars from A, B, C on the Simson line, tangential to the three-cusped hypocycloid.

Daniel Arany.

1267. *A well-known invariant.*

If we make the substitutions typified by $x_\rho = l_{\rho i}x_i'$, where ρ and i each range from 1 to r inclusive, in the expression $a_{\mu\nu}x_\mu x_\nu$, where μ and ν also range from 1 to r, we obtain $a_{\mu\nu}l_{\mu i}x_i' l_{\nu j}x_j'$.

Interchanging μ and i, ν and j, this becomes $a_{ij}l_{i\mu}x_\mu' l_{j\nu}x_\nu'$. Hence if we call it $a_{\mu\nu}'x_\mu' x_\nu'$, we have $a_{\mu\nu}' = a_{ij}l_{i\mu}l_{j\nu}$.

Thus taking the columns of $|a_{\mu\nu}|$ with the μth column of $|l_{\mu\nu}|$, the μth column of the product is

$$a_{i1}l_{i\mu},\ a_{i2}l_{i\mu},\ \dots,\ a_{ir}l_{i\mu}.$$

Taking this with the νth column of $|l_{\mu\nu}|$, an element of $|a_{\mu\nu}|\,|l_{\mu\nu}|^2$ is

$$\begin{aligned} &l_{i\mu}(a_{i1}l_{1\nu} + a_{i2}l_{2\nu} + a_{i3}l_{3\nu} + \dots + a_{ir}l_{r\nu})\\ &\quad = l_{i\mu}a_{ij}l_{j\nu} = a_{\mu\nu}'. \end{aligned}$$

Hence $$|a_{\mu\nu}|\,|l_{\mu\nu}|^2 = |a_{\mu\nu}'|.$$

Taking $r=3$, we have

$$a_{11}' + a_{22}' + a_{33}' = a_{ij}(l_{i1}l_{j1} + l_{i2}l_{j2} + l_{i3}l_{j3}).$$

When $$\begin{aligned} l_{i\mu}l_{j\mu} &= 1 \quad (j=i)\\ &= 0 \quad (j \neq i) \end{aligned}$$

the transformation is said to be orthogonal, and then

$$a_{\mu\mu}' = a_{ii} = a_{\mu\mu}.$$

We also have

$$\begin{vmatrix} l_{11} & l_{12} & l_{13} \\ l_{21} & l_{22} & l_{23} \\ l_{31} & l_{32} & l_{33} \end{vmatrix} \begin{vmatrix} l_{11} & l_{12} & l_{13} \\ l_{21} & l_{22} & l_{23} \\ l_{31} & l_{32} & l_{33} \end{vmatrix} = \begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{vmatrix} = 1.$$

Hence for this kind of transformation $|a_{\mu\nu}'| = |a_{\mu\nu}|$.

Again

$$\begin{vmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{vmatrix} \begin{vmatrix} l_{11} & l_{12} & l_{13} \\ l_{21} & l_{22} & l_{23} \\ l_{31} & l_{32} & l_{33} \end{vmatrix}^2 = \begin{vmatrix} a_{11}l_{11} & a_{2i}l_{1i} & a_{3i}l_{1i} \\ a_{11}l_{21} & a_{2i}l_{2i} & a_{3i}l_{2i} \\ a_{11}l_{31} & a_{2i}l_{3i} & a_{3i}l_{3i} \end{vmatrix} \begin{vmatrix} l_{11} & l_{12} & l_{13} \\ l_{21} & l_{22} & l_{23} \\ l_{31} & l_{32} & l_{33} \end{vmatrix}$$

$$= \begin{vmatrix} a_{11} & a_{21}' & a_{31}' \\ 0 & a_{22}' & a_{32}' \\ 0 & a_{23}' & a_{33}' \end{vmatrix}.$$

Hence $$a_{22}a_{23} - a_{23}^2 = a_{22}'a_{33}' - a_{23}'^2,$$

or, since $$|a_{\mu\nu}| = |a_{\mu\nu}'|,$$

$$a^{11} = a'^{11}.$$

Similarly $$a^{22} = a'^{22}, \quad a^{33} = a'^{33}.$$

Hence $$a'^{\mu\mu} = a^{\mu\mu}.$$

Thus if the variables in $a_{\mu x}x_\mu x_\nu$ are changed orthogonally, then $a_{\mu\mu}$, $a^{\mu\mu}$, $|a_{\mu\nu}|$ are unchanged. N. M. Gibbins.

1268. *An experiment.*

A few weeks ago it occurred to us that our third-year pupils (children of 13-14) would welcome a change from the usual routine and it was suggested to them that they might like to write short papers or prepare little talks on mathematical subjects. The papers were to be handed to two of the mathematical staff who would select from the material provided enough to occupy an afternoon of about an hour and a half.

The idea was seized upon eagerly by quite a number of the children and there was no difficulty in finding plenty to fill the time allotted.

We have four " parallel " forms in the third year and these all assembled, together with the mathematical staff, and listened with evident appreciation and interest to the papers and talks arranged. These included a simple account of the conic sections given by two girls, one of whom read the paper while the other drew the cones on the blackboard and showed the sections, besides showing how a circle could be constructed by means of a drawing pin and a loop of string, while an ellipse needed two drawing pins and the loop of string.

The titles of some of the other papers were " A conversation with the dimensions " (material culled from Abbott's *Flatland*, I think), " The regular solids and how it is that there are just five of them ", " Graphs ", " Two fallacies ", " The life of Galileo ", " The force of cohesion ", " The mystery of gravitation ", " The moon ", and

" Magic squares ". The paper on graphs was illustrated by means of the epidiascope which one of the mistresses operated for the child concerned. The fallacies were (i) the proof that $2=4$, (ii) the proof that a right angle is equal to an obtuse angle.

Scenes were acted from the stories of Archimedes—the dishonest goldsmith, of course—and the killing of Archimedes at the siege of Syracuse.

Some of the material was sent in too late to be considered or was rejected for other reasons. This has been, or will be, read or displayed to her own form by the author in the course of the ordinary lesson periods. These papers include " Geometrical pattern drawing ", " The use of trigonometry ", " Our national finances ", " The planet Mars ", " How mathematics is used in physics ", " What the Greeks discovered in mathematics ", " A geometrical construction ", " How to enlarge or reduce a given figure ", and a practical demonstration that a square pyramid has one-third the volume of a prism with the same base and height.

All the work produced was, of course, quite childish and immature, but we were gratified by the results of our experiment. There seems to be no doubt that this kind of thing is not entirely out of the range of children of the age specified, if they are guided and encouraged in their choice of reading, and we are in hopes that a permanent deepening of interest will have been achieved in many cases.

E. M. READ.

1269. *The indirect proof.*

A very interesting and stimulating paper on the indirect proof was published in the February number of the *Mathematical Gazette* ; this was directed towards showing that, provided that more care was taken in the conduct of the proof than is usually done, this method is perfectly good and useful.

While many of the points which the author makes are eminently sound, it is felt that one of his main doctrines is distinctly doubtful. He says, that as distortion is necessary in the figure to an indirect proof, it should be confined to the construction and in no case should the data be falsified. To take one of the examples which he gives, suppose it be required to prove indirectly the theorem :

If $ABCD$ is a quadrilateral in which the opposite angles B and D are supplementary, then its vertices are concyclic.

The indirect method of proof consists of supposing that the circle through A, B, and C does not pass through D and then showing that this leads to an absurdity.

Now, it is obvious that a true figure of this supposition *cannot* be drawn, as the theorem is in fact true. It is necessary therefore to distort some part of the figure so that as a result D does not lie on the circle. A common way, and one to which the writer of the paper strongly objects, is to draw the quadrilateral with its angles not truly supplementary. He prefers to draw the circle ABC not truly circular and claims that in doing so he is not distorting a datum but

only a construction. (I hope I have grasped the argument properly.) Is not this, however, taking rather a narrow view of what constitutes the data? If we recast the theorem to be proved this will perhaps appear more clearly. Write it thus :

Let $ABCD$ be a quadrilateral having angles B and D supplementary, then shall the circle through A, B, and C pass also through D.

In this form it is more clear that the fact that the curve through A, B, and C is a circle is one of the data. It is one of the facts used in the proof, has not been previously proved in the same proof, and thus is either a datum or a fact derived from a construction. It cannot be the latter, however, because it enters into the enunciation ; moreover, if we withdraw the fact the theorem ceases to be true. It remains possible that it is a fact more legitimately to be distorted, because less important than the other data or for some other reason. But it seems reasonable to consider that all the data are equally important.

The doubt partly arises, I think, from the fact that the enunciation first given is partly a particular one and partly a general one. It was recast as a particular enunciation but might have been put as a general enunciation thus :

If the opposite angles of a quadrilateral are supplementary, it is cyclic.

In this form all the data are reduced to an equal footing and all take on to some extent the appearance of being constructions, which of course they are not really. The fact is, that to say that a quadrilateral is cyclic, is to use a general form of enunciation ; the equivalent particular enunciation is to say that the circle through A, B, and C, say, passes through D.

The question of what is the best way out remains to be settled. Personally, I should always draw figures freehand, which solves all the problems fairly satisfactorily, and has other advantages as well. This course may perhaps seem more acceptable when we consider that any figure is only an approximation to the abstract geometrical ideas with which we deal. C. D. MATHEWS.

1270. *A problem in algebra.*

In the course of some geometrical work on the reduction of trivectors, I was forced to tackle the following problem in algebra. It was new to me, but it may be well-known to some people. My solution is rather unwieldy ; I wonder whether a better one is known.

The problem is : given a set of n numbers, to find how many groups of three numbers may be chosen such that no two groups contain more than one common number.

The analysis for $n=1, \ldots 12$ follows. The groups for a certain value of n consist of those written opposite that value together with all those above it. For example, the groups for $n=6$ consist of 123, 145, 346, 256. Sets of groups like 234, 256, 451, 361 which are obtained from the first set by changing round the numbers are not allowed to count as separate sets.

n	Groups	No. of Groups	n	Groups	No. of Groups
3	123	1	10	7 8 10 6 9 10	10
4		1			
5	145	2	11	1 10 11 2 8 11 3 9 11	13
6	346 256	4			
7	167 247 357	7 (saturated)	12	7 9 12 6 8 12 5 10 12 4 11 12	17
8		7			
9	189	8			

The following scheme shows how the groups are arrived at up to $n=31$. Mr. P. L. Spencer has constructed the table up to $n=63$ and confirmed my final formula up to that stage.

	1	2	3
5	4·5		
6		5·6	4·6
7	6·7	4·7	5·7

	1	2	3	4	5	6	7
9	8·9						
10						9·10	8·10
11	10·11	8·11	9·11				
12				11·12	10·12	8·12	9·12
13	12·13	9·13	8·13	10·13	11·13		
14		12·14	10·14	9·14	8·14	13·14	11·14
15	14·15	10·15	12·15	8·15	9·15	11·15	13·15

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
17	16·17														
18														17·18	16·18
19	18·19	16·19	17·19												
20												19·20	18·20	16·20	17·20
21	20·21	17·21	16·21	19·21	18·21										
22										20·22	18·22	17·22	16·22	21·22	19·22
23	22·23	18·23	20·23	16·23	17·23	19·23	21·23								
24								23·24	22·24	18·24	20·24	16·24	17·24	19·24	21·24
25	24·25	20·25	18·25	17·25	16·25	21·25	22·25	19·25	23·25						
26						22·26	24·26	21·26	20·26	17·26	16·26	18·26	19·26	25·26	23·26
27	26·27	22·27	24·27	18·27	19·27	16·27	17·27	20·27	21·27	23·27	25·27				
28				26·28	24·28	20·28	19·28	22·28	18·28	16·28	17·28	27·28	21·28	23·28	25·28
29	28·29	24·29	22·29	20·29	26·29	17·29	16·29	18·29	19·29	21·29	23·29	25·29	27·29		
30		28·30	26·30	22·30	20·30	24·30	18·30	17·30	16·30	25·30	19·30	21·30	23·30	29·30	27·30
31	30·31	26·31	28·31	24·31	22·31	18·31	20·31	16·31	17·31	19·31	21·31	23·31	25·31	27·31	29·31

Saturation.

By "saturated" is meant that every one of the n numbers is combined with every one of the $n-1$ others. The values of n for which this occurs can be seen from the following considerations.

(i) Let the saturation occur at $n = n_1, n_2, \dots n_r$.

(ii) The case $n = n_{r-1}$ requires n_{r-1} numbers, the case $n = n_r$ requires $n_r - n_{r-1} = m$ (say) extra numbers.

(iii) The additional groups between n_{r-1} and n_r are obtained by taking the combinations two at a time of the extra numbers and putting in front of them certain of the first n_{r-1} numbers. The latter have already been combined in every possible way; thus each of these can be used only once in the groups between $n = n_{r-1} + 1$ and $n = n_r$. (See scheme.)

(iv) The additional number of groups added to the number for $n = n_r - 1$ to get the number for $n = n_r$ is ${}^mC_2 - {}^{m-1}C_2 = m - 1$.

(v) For saturation to occur this number must be n_{r-1}, otherwise the first n_{r-1} numbers cannot all be used.

Thus $$n_{r-1} = m - 1 = n_r - n_{r-1} - 1,$$

and $$n_r = 2n_{r-1} + 1.$$

But clearly saturation occurs for $n_1 = 3$. Thus it occurs for

$$n = 2^{r+1} - 1.$$

Note.—I have not succeeded in proving theoretically that saturation *must* occur.

Formula for the number of groups.

Consider the scheme between $n = 7$ and $n = 15$. The groups are made up of the combinations two at a time of the numbers after 7 combined with one of the numbers 1 to 7. For example the groups added between $n = 7$ and $n = 11$ have as their second two members the ${}^4C_2$ combinations of the numbers 8, 9, 10, 11. Saturation occurs at $n = 2^r - 1$. Thus to obtain the number of groups in the general case we express n in the form $2^r + k$. The number then is

$$N = 1 + {}^4C_2 + {}^8C_2 + \dots + {}^{2r-1}C_2 + {}^{k+1}C_2.$$

If the series for N is summed we obtain the result: when $n = 2^r + k$, the number of groups is $\frac{1}{3}(2^r - 1)(2^{r-1} - 1) + \frac{1}{2}k(k+1)$.

Note.—The general problem "Given n numbers, to find the maximum number of groups of p no two of which have more than q common numbers" looks formidable. L. R. PEARS.

1271. *A theorem in arithmetic.*

Dr. A. Lindenbaum noticed the following result as a particular case of a theorem established by him (*Fundamenta Math.*, 20 (1935), 15):

"it is possible to find two subsets N', N'' of the set N (consisting of the positive and negative integers and zero) whose only common

member is zero and which are such that the equation $n=x+y$ has, for each $n\epsilon N$, exactly one solution with $x\epsilon N'$, $y\epsilon N''$ ",
and gave the following elementary proof. The connection of the ideas in it with those of familiar problems in Arithmetic perhaps justifies this attempt to bring it to the notice of the readers of the *Gazette*.

Any non-zero $n\epsilon N$ can be represented uniquely in the form

$$(\alpha) \qquad n=\sum_{i=1}^{r} \epsilon_i \,.\, 3^{k_i}$$

where $\epsilon_i=\pm 1$ and the $\{k_i\}$ are integers such that $0 \leqslant k_1 < k_2 < \ldots < k_r$. So, any non-zero $n\epsilon N$ can be represented uniquely in the form

$$n=\sum_{i=1}^{s} \epsilon_i' \,.\, 3^{2l_i}+\sum_{i=1}^{t} \epsilon_i'' \,.\, 3^{2m_i+1},$$

where $\epsilon_i'=\pm 1$, $\epsilon_i''=\pm 1$ and the $\{k_i\}$ and $\{m_i\}$ are integers such that $0 \leqslant l_1 < l_2 < \ldots < l_s$, $0 \leqslant m_1 < m_2 < \ldots < m_t$.

We can therefore take N' to consist of 0 and all those numbers n for which all the $\{k_i\}$ of (α) are even and N'' to consist of 0 and all those numbers n for which all the $\{k_i\}$ of (α) are odd. Thus N' consists of the numbers

0 ; 1 ; 8, 9, 10 ; 71, 72, 73, 80, 81, 82, 89, 90, 91 ; 638, ...

and their negatives ; N'' consists of the numbers obtained by multiplying each number of N' by 3.

The method of expressing any number n, say 1000, in the form $n=x+y$ is obvious. We write $1000=3^6+3^5+3^3+3^0=(3^6+3^0)+(3^5+3^3)$ and $3^6+3^0=730$ and $3^5+3^3=270$ belong to N' and N'' respectively.

JOHN TODD.

1272. *Curiosités arithmétiques.*

1. Les additions suivantes contiennent, avec le total, dix et onze nombres formés des chiffres 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, pris une fois.

0123456789	0123456789	0246913578
0493827156	0246913578	0493827156
0617283945	0493827156	0617283945
0864197523	0617283945	0864197523
0987654312	0864197523	0987654312
1234567890	0987654312	1234567890
1358024679	1234567890	1358024679
1728395046	1604938257	1975308624
2469135780	1728395046	2098765413
	1975308624	
9876543120	9876543120	9876543120

Si l'on pose

$$N = 0123456789,$$

ces opérations résultent de ce que

$$\begin{aligned} N+4N+5N+7N+8N+10N+11N+14N+20N &= 80N,\\ N+2N+4N+5N+7N+8N+10N+13N+14N+16N &= 80N,\\ 2N+4N+5N+7N+8N+10N+11N+16N+17N &= 80N. \end{aligned}$$

Or, chacun de ces multiples particuliers du nombre N est formé de dix chiffres tous différents.*

2. Voici deux exemples de multiplications curieuses,

$$0246913578 \times 0864197523 = 0493827156^2,$$
$$0123456789 \times 3086419725 = 0617283945^2,$$

qui proviennent de ce que

$$2N \times 8N = 16N^2 = (4N)^2,$$
$$N \times 25N = 25N^2 = (5N)^2.$$

V. Thébault.

1273. *Roots of a certain continuant.*

Let $$D_n \equiv \begin{vmatrix} z, & \alpha, & 0, & 0, \ldots\ldots\ldots & 0, & 0 \\ \beta, & z, & \alpha, & 0, \ldots\ldots\ldots & 0, & 0 \\ 0, & \beta, & z, & \alpha, \ldots\ldots\ldots & 0, & 0 \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ 0, & 0, & 0, & 0, \ldots\; \beta, & z, & \alpha \\ 0, & 0, & 0, & 0, \ldots\; 0, & \beta, & z \end{vmatrix} = 0.$$

Evidently $D_n = z \,.\, D_{n-1} - \alpha\beta \,.\, D_{n-2}$; $D_1 = z$, $D_0 = 1$.

If we put $z = x + \dfrac{\alpha\beta}{x}$,

$$D_1 = x + \frac{\alpha\beta}{x}, \quad D_2 = x^2 + \alpha\beta + \frac{\alpha^2\beta^2}{x^2},$$

$$D_3 = x^3 + \alpha\beta \,.\, x + \frac{\alpha^2\beta^2}{x} + \frac{\alpha^3\beta^3}{x^3}, \text{ etc.}$$

By induction

$$D_n = x^n + \alpha\beta \,.\, x^{n-2} + (\alpha\beta)^2 x^{n-4} + \ldots + \frac{(\alpha\beta)^{n-2}}{x^{n-4}} + \frac{(\alpha\beta)^{n-1}}{x^{n-2}} + \frac{(\alpha\beta)^n}{x^n}.$$

Putting $\dfrac{x}{\sqrt{\alpha\beta}} = y$,

$$D_n = (\alpha\beta)^{n/2}\left[y^n + y^{n-2} + y^{n-4} + \ldots + \frac{1}{y^{n-4}} + \frac{1}{y^{n-2}} + \frac{1}{y^n}\right] = 0,$$

* Cf. V. Thébault, *Mathesis*, 1937, p. 7.

or, $$y^{2n}+y^{2n-2}+\ldots+y^2+1=0.$$

Multiplying by y^2-1, $y^{2n+2}-1=0$,

the roots of which are $y=\cos\dfrac{\pi r}{n+1}+i\sin\dfrac{\pi r}{n+1}$, $1\leqslant r\leqslant 2n+2$.

The values of z will, therefore, be given by

$$z=2\sqrt{\alpha\beta}\,.\,\cos\frac{\pi r}{n+1},\quad 1\leqslant r\leqslant n.$$

D. N. S.
R. K.

1274. *An exercise in elementary geometry.*

It is difficult to find a new exercise in elementary geometry and I am surprised that the following appears to have escaped the notice of writers of textbooks.

A single construction for the four common tangents to two circles.

Draw the direct common tangents in the usual way. Then cross-join the meets of these with the circle whose diameter is the line joining the centres of the given circles (used in the former construction). These are the transverse tangents.

The principle involved allows of expression in several forms. *E.g.* (1) Prove that of the six meets of the four common tangents to two circles those which do not lie on the line of centres are concyclic with the centres of the circles.

(2) Given two circles and two common tangents (*e.g.* one direct and one transverse) construct the other two. B. A. SWINDEN.

1275. *The partition of cubes.*

With reference to notes 1187 (May 1936) and 1232 (February 1937) we find

$$(20n^2+10n-3)^3+(16n^2+8n+6)^3$$
$$=(5+10n-12n^2)^3+(24n^2+8n+4)^3 \;\ldots\ldots(1)$$

and $$(4n^2-22n+9)^3+(48n^2-40n+10)^3$$
$$=(36n^2-22n+1)^3+(40n^2-40n+12)^3 \ldots(2)$$

It is possible from these to find expressions for a cube as the sum of three positive cubes (*Gazette*, February 1937, p. 33) if in (1) n does not lie between 1·185 and $-$·35 and in (2) n lies between 5·05 and ·56 (the limits are approximate in all cases).

The following are a few results :

$$1010^3=1^3+791^3+812^3,$$
$$34404^3=3^3+26933^3+27670^3,$$
$$206^3=5^3+163^3+164^3,$$
$$471814^3=7^3+369345^3+279476^3.$$

(1) gives at once

$$(148 \pm 20\sqrt{85})^3 + (194 \pm 16\sqrt{85})^3 = (231 \pm 21\sqrt{85})^3$$

(upper signs together),

and other similar results can be obtained from the formulae : all of them include $\sqrt{85}$.

Both (1) and (2) gives absolute identities of the form $a^3 + b^3 = b^3 + a^3$ when $n = \pm\frac{1}{2}$.

B. A. SWINDEN.

1276. *On a cubic diophantine equation.*

The process considered by Mr. E. P. Lewis in the *Gazette* (February, 1937, p. 60, Note 1232) for the solution in integers of the equation

$$x^3 + y^3 = u^3 + v^3$$

can be generalised by the method I have given in *Sphinx*, 1937, p. 4 and *Mathesis*, 1937, p. 82 ; this method will be easily applied to any homogeneous cubic diophantine equation.

Let $x = a$, $y = b$, $u = c$, $v = d$ and $x = \alpha$, $y = \beta$, $u = \gamma$, $v = \delta$ be any two solutions of the given equation ; then

$$x = a + \alpha\lambda,\ y = b + \beta\lambda,\ u = c + \gamma\lambda,\ v = d + \delta\lambda$$

will be a new solution, provided

$$\lambda = -\frac{a^2\alpha + b^2\beta - c^2\gamma - d^2\delta}{a\alpha^2 + b\beta^2 - c\gamma^2 - d\delta^2}.$$

Hence, any pair of solutions being known, we find the new solution

$$x = a(b\beta^2 - c\gamma^2 - d\delta^2) - \alpha(b^2\beta - c^2\gamma - d^2\delta),$$
$$y = b(a\alpha^2 - c\gamma^2 - d\delta^2) - \beta(a^2\alpha - c^2\gamma - d^2\delta),$$
$$u = c(a\alpha^2 + b\beta^2 - d\delta^2) - \gamma(a^2\alpha + b^2\beta - d^2\delta),$$
$$v = d(a\alpha^2 + b\beta^2 - c\gamma^2) - \delta(a^2\alpha + b^2\beta - c^2\gamma).$$

The process considered by Mr. Lewis corresponds to the case when the solution $(\alpha, \beta, \gamma, \delta)$ is one of the obvious ones $(1, 1, 1, 1)$ or $(1, -1, 1, -1)$ or $(1, -1, -1, 1)$.

R. GOORMAGHTIGH.

BUREAU FOR THE SOLUTION OF PROBLEMS.

THIS is under the direction of Mr. A. S. Gosset Tanner, M.A., 115, Radbourne Street, Derby, to whom all inquiries should be addressed, accompanied by a stamped and addressed envelope for the reply. Applicants, who must be members of the Mathematical Association, should wherever possible state the source of their problems and the names and authors of the textbooks on the subject which they possess. As a general rule the questions submitted should not be beyond the standard of University Scholarship Examinations. Whenever questions from the Cambridge Mathematical Scholarship volumes are sent, it will not be necessary to copy out the question in full, but only to send the reference, *i.e.* volume, page, and number. The names of those sending the questions will not be published.

The Secretary would be glad to receive any solutions that have not yet been returned.

REVIEWS.

Approximate Computation. By A. Bakst. Pp. xvi, 287. $1.75. 1937. Twelfth Yearbook of the National Council of Teachers of Mathematics. (Bureau of Publications, Teachers College, Columbia University, New York)

There are some mathematical ideas which are so fundamental that they pervade the whole of mathematical study. One such idea is functionality, another is approximation. An exact value such as 6 inches is an ideal which we never come across. All our values are approximate. Every scientific worker must unavoidably use them, and an appreciation of them is essential if he is to interpret his work intelligently. Every engineer, every constructor—even woodworker—uses them more or less consciously, striving for greater accuracy where required, or using crude values where these will serve, with the greater speed desirable. Unless our teaching is to be devoid of the practical application of number, we must give consideration to the study of approximations. A universal idea is not easy for examiners to test and is difficult for teachers to teach. For one thing, it cannot be as easily placed in the schedule of teaching time as, say, quadratic equations. That is why functionality is not usually taught well, and approximations taught hardly at all. Another essential for successfully teaching a universal subject is for the teacher to be steeped in the subject. It is then possible for illustrations to be given as opportunities arise. Dr. Bakst tells us that in France there is a compulsory course in the subject for mathematical teachers, while in Soviet Russia the course occupies 90 hours a session. The National Council of Teachers of Mathematics (U.S.A.), realising the importance of the subject, have devoted their twelfth yearbook to it and the production was carried out by Aaron Bakst, Ph.D. Mathematical teachers will be grateful to him for the thorough and painstaking way he has devoted himself to his task. He has consulted books in many languages, and the bibliography at the back of the book, alone, gives the book a claim to the shelves of the mathematical library.

From the nature of approximate numbers it is natural that an appreciation of their meaning must be based on a study of measurements, units, and the effect of operating with them. Dr. Bakst devotes some 40 pages to fundamental ideas and terms, and hints on teaching them. His terms include *precision* (smallness of absolute error) and *accuracy* (smallness of relative error). Non-significant zeros are written smaller; thus $370{\scriptstyle 0}$ is correct to three significant figures. It would be useful to extend the idea to other digits. Thus $268{\scriptstyle 7}$ should mean that the 7 is subject to a slight error of, say, 1 and is better than $269{\scriptstyle 0}$ where the region of uncertainty is 5 times as great. Also notice the use of the bar to distinguish between different 5's, as in

$$3{\cdot}7346 \simeq 3{\cdot}73\bar{5} \simeq 3{\cdot}73$$

and

$$3{\cdot}7352 \simeq 3{\cdot}735 \simeq 3{\cdot}74.$$

Dr. Bakst repeatedly emphasises the importance of significant figures—not decimal places—and relative error to describe accuracy.

There are two kinds of error. One occurs in 3·42 in., where, apart from the maximum of 0·005 in., the error is unknown in size and sign. The other is in the curtailment of a number, as in $\pi \simeq 3{\cdot}142$, where both the size and sign of the error are known. In operations with the former type of number the errors are cumulative. With the latter numbers it is possible for the errors to balance out. I must decidedly differ from the author, who postulates that the errors are always cumulative and must be given the same sign. He submits the following in support of his claim :

	Number	Error	Relative error
	22·4	−0·04	−0·001786
	27·9	+0·05	+0·001792
Product	624·96	+0·004	+0·000006

which he says gives an impossibly small relative error for the product of 3-figure numbers. The absurdity, however, is in the last column, which contains 4-figure numbers deduced from errors of 1-figure accuracy. He also advocates that successive reduction in significant figures should proceed as follows:

$$\begin{aligned} 25{\cdot}537 \pm 0{\cdot}042 &\simeq 25{\cdot}53 \pm 0{\cdot}049 \\ &\simeq 25{\cdot}5 \ \ \pm 0{\cdot}08 \\ &\simeq 25 \pm 0{\cdot}58 \text{ or } 25 \pm 0{\cdot}6, \text{ etc.} \end{aligned}$$

This tendency to broaden the region of error occurs when the author deals with mathematical tables, and he gives a 3-figure answer obtained from 4-figure tables even with the simplest application. This broadens the error five times and is unnecessary. Speaking of tables reminds me of an excellent method in the Akribos Log card sold by Philip and Tacey (2d.). Although this folded card measures only 3½ in. by 5½ in., it is the most accurate table of 4-figure logarithms I have seen. Before some numbers, including those in the difference columns, there is an upper dot, thus ·8, and before others a lower dot, thus .8. The first indicates a plus error of over a quarter unit, the latter a corresponding minus error. In reading off logarithms of 4-figure numbers it is easy to make a correction of ± 1 according as 2 upper or 2 lower dots occur together. Use of these tables makes 4-figure accuracy almost a certainty. Although these cards have been in existence for at least 20 years, it is surprising that this very good idea has not been adopted for all tables. Compilers of tables, please note and please copy.

Dr. Bakst gives the following rule for multiplication and division of two numbers when one—it does not matter which—is correct to k significant figures and the other to $k+r$ figures ($r=0, 1, 2, \ldots$). "If the product of the standard form equivalents $\geqslant 10$, the answer is correct to k significant figures, otherwise to k–1 figures" (my wording). Applying the rule to multiplication, I give the following cases where it is not quite right:

$$\begin{aligned} 3{\cdot}44 \ldots \times 3{\cdot}04 \ldots &= 10{\cdot}458 \pm 0{\cdot}03, \\ 9{\cdot}96 \ldots \times 9{\cdot}89 \ldots &= 98{\cdot}504 \pm 0{\cdot}1, \\ 9{\cdot}94 \ldots \times 1{\cdot}12 \ldots &= 11{\cdot}13 \ \ \pm 0{\cdot}05, \\ 1{\cdot}02 \ldots \times 1{\cdot}02 \ldots &= \ \ 1{\cdot}04 \ \ \pm 0{\cdot}01. \end{aligned}$$

I have picked extreme cases giving maximum errors, so although the rule is not dead right, I consider it extremely good. It is necessary to bear in mind that "k-figure accuracy" is a rough description, and one such number may be 10 times as accurate as another. In multiplying two k-figure numbers one result may be 100 times another. These, and other reasons, make difficult the formulation of a rule which is always right and yet does not unduly reduce the accuracy of the answer. I doubt whether it would be possible to better Dr. Bakst's multiplication rule. The rule is not nearly so correct when applied to division. Thus $9{\cdot}96 \div 1{\cdot}11 = 8{\cdot}97 \pm 0{\cdot}4$; but since $9{\cdot}96 \times 1{\cdot}11 > 10$, the rule gives 3-figure accuracy.

The style of the book is often involved. One has not infrequently to contend with mental twisters such as "The termination of the significant digits on the right of an approximate number in the place of significance where the

significant digit on the left of the apparent error is located." There is a great deal of unnecessary repetition, and of cases, so like previous ones, as to be unnecessary. The investigations, too, are unnecessarily long, mainly due to the fact that they are based on a consideration of the absolute instead of the relative error. The value of the book could be increased r^2 times where r is the ratio of the reduction of pages. I should put $r=3$. S. INMAN.

Higher Algebra. By S. BARNARD and J. M. CHILD. Pp. xiv, 585. 20s. 1936. (Macmillan)

This book claims to be a text-book of Algebra for students working for Higher School Certificate, mathematical scholarships and examinations of similar standard. The authors are exceptionally modest, for it is far more than a text-book—it might perhaps better be described as an encyclopaedia. Moreover, its scope is not confined to the syllabus for mathematical scholarships; for example, Abel's and Dirichlet's tests for convergence are included, Merten's theorem finds a place, and many chapters contain theorems which are unlikely to be required for scholarship examinations.

Not only is the scope wide, the attention to detail also is remarkable, and the authors are to be congratulated on the skill with which they have combined these two characteristics in a book of less than 600 pages. In order to achieve this result, and to preserve a logical sequence, it has been necessary to divide each of the topics discussed into three or more chapters which are scattered rather irregularly throughout the book. Thus the Theory of Numbers occupies Chapters I, XXVI, and XXVII; Equations and the Theory of Equations, Chapters VI, X, XI, XII, XVIII and XXVIII; Sequences, Limits and Convergence, Chapters XV, XVI, XX and XXX. Combining these, the scope of the book is roughly as follows:

(1) Theory of numbers, including Fermat's, Wilson's and Lagrange's theorems, congruences and the elementary part of the theory of residues.

(2) Rational numbers; Dedekind's theory of irrational numbers and Dedekind's theorem.

(3) Partial Fractions.

(4) Determinants, including expansion in terms of second minors, symmetric and skew-symmetric types.

(5) Theory of equations, including complete accounts of the cubic and biquadratic; Descartes' and de Gua's rules, Sturm's and Fourier's theorems, and various methods of solving numerical equations.

(6) Convergence, including Cauchy's condensation test, Abel's and Dirichlet's tests, Merten's and Abel's theorems on the multiplication of series, and infinite products, but excluding double series.

(7) Inequalities.

(8) Limits, continuity and differentiation, including Taylor's theorem.

(9) The exponential, logarithmic, binomial and multi-nomial theorems.

(10) Various other topics, *e.g.* substitutions and transpositions, summation of series, finite differences, probability, curve tracing, distributions, the partition of numbers, continued fractions and indeterminate equations of the first and second degrees.

This brief summary may help to give some idea of the wide ground covered, but it is impossible to convey any impression of the wealth of detail contained both in the book-work and in the worked examples. In addition there are about 1500 examples to be worked by the student, many of which are of

great interest. In this connection, however, it may be remarked that the authors have sometimes been a little too generous in supplying hints for solution.

Many things in the book are excellently done. The chapters on convergence, for example, are very full and well arranged, and the treatment of limits of indetermination is exceptionally clear. Chapter XXVII sets out clearly and concisely all the well-known facts about recurring decimals of which the student will not readily find proofs elsewhere. Bernoulli's numbers are defined as the coefficients of n in the expansions of $S_r(=\sum_{k=1}^{n} k^r)$. The numbers in order thus are

$$\tfrac{1}{2},\ \tfrac{1}{6},\ 0,\ -\tfrac{1}{30},\ 0,\ \tfrac{1}{42},\ 0, \text{ etc.}$$

This notation has many advantages, notably that Bernoulli's symbolic theorem

$$(r+1)\,S_r=(n+B)^{r+1}-B^{r+1}$$

takes such a convenient form. Moreover it affords a ready connection between Bernoulli's and Euler's numbers.

A few adverse criticisms must be made, but they must be regarded as indicating slight blemishes in a book that is otherwise admirable.

It must be confessed that parts of the book make very heavy reading. In some cases this is due to a desire for conciseness, leading to the omission of steps; thus on p. 90, $\phi(x)$ should be explicitly defined, and the statement on line 11 should either have been proved or else a reference should be inserted after line 12 to p. 88 (ii). A proof might also have been supplied for p. 48 (5): it would only have taken up two lines. Pp. 133 and 142 require careful reading, and the second proof of the binomial theorem (p. 342) requires closer attention than the average VIth form student is likely to bestow on a theorem the truth of which he is all too ready to assume. The vital step in Vandermonde's theorem (p. 340), (the transition from positive integral to other values of m and n) is left unproved; or rather it should be said that the statement at the foot of p. 340 only shows that if one of m, n is a positive integer the theorem holds for all values of the other. A reference to p. 28, 9 (2) might help here, though it would not fill the gap completely.

The proof of the exponential theorem given on pp. 307, 308, besides being needlessly involved, is definitely unsound, the statement on p. 308, line 6, being untrue, as may be easily verified by setting (for example) $x=-6$, $n=3$. In this connection I feel strongly that it is time to call a halt in the construction of new proofs of the binomial and exponential theorems which has been so marked a feature of many recently published Algebras. These proofs have no advantages over the old proofs by multiplication of series, while they suffer from numerous disadvantages, of which the following are the most important:

(1) they are simply *ad hoc* demonstrations, and illustrate no general mathematical theory;

(2) they are so involved as to be almost impossible to follow, and absolutely impossible to remember;

(3) they are often unsound; and

(4) they are very unaesthetic.

In a book of this size the reading of the proofs is such an arduous business that a certain number of errata and misprints are bound to escape the vigilance of the authors. As these are liable at best to delay and at worst to mislead the

inexperienced student who is reading this book without the guidance of a teacher, I append a list of those I have detected:

P. 6, l. 7 up, for n read N.

P. 46, l. 5 up, insert reference to pp. 95, 96.

P. 91, last line, *for* or *read* if.

P. 140, l. 9, *for* (see Exercise XI, 4). *read* (see p. 94, Exercise XI, 2)

P. 146, Ex. 20, for $ax^2+2hxq+by^2+2qx+2fy+c$

read $ax^2+2hxy+by^2+2gx+2fy+c$.

P. 201, ll. 2, 3, *for* diagonal of a square whose side is 7 units

read side of a square whose area is 7 square units.

P. 236, l. 14, *for* $\frac{1}{2}\epsilon$ *read* ϵ;

l. 19, *for* $\dfrac{1}{2^n}\epsilon$ *read* $\dfrac{1}{2^{n-2}}\epsilon$.

P. 239, Fig. 39 is inaccurate.

P. 258, 19, Ex. 1. (C) is not a rearrangement of (A).

P. 263, l. 23, *for* $\dfrac{r+1}{n-1}$ *read* $\dfrac{r+1}{r-n}$.

P. 311, l. 14, *for* great *read* small.

P. 319, l. 8, *for* $\sqrt{AB}$ *read* $\sqrt{10B}$.

P. 343, l. 11, for $-ns_{n-1,\,r-1}$ read $-ny_{n-1,\,r-1}$;

l. 2 up, for $-\dfrac{n+1}{r+2}xt_{n,\,r+1}$ read $-\dfrac{n+1}{r+1}xt_{n,\,r+1}$.

P. 344, l. 1, *for* If $n>1$ *read* If $n>-1$;

l. 4, for $-m-1<n\leqslant m$ read $-m-1<n\leqslant -m$.

P. 415, Ex. 1 (i) for $13x-17=5$ read $13x-17y=5$.

P. 426, l. 21, for $\overset{p}{C}_1$ read $\overset{p}{C}_2$.

The arrangement of the book and the practice of restarting from 1 in numbering the articles in each chapter demand that references shall be frequent and easily found. It is to be regretted that the authors have failed here. The references actually given are insufficient, and as the number of the current chapter is not indicated on the top of each page, those which do occur can only be located by applying to the table of contents.

It may be mentioned that the chapter on Finite Differences, while forming an excellent introduction to the subject, does not include either central difference formulae (except a special case of Bessel's formula) or any of the integration formulae (such as Weddle's rule), so that it does not cover the ground required for Part I of the examination for the Institute of Actuaries.

It may be doubted if such a book as this, covering a wide field and containing great wealth of detail, will prove suitable for teaching purposes, and it is true that pressure on the scholarship teacher's time will necessitate certain omissions. A suitable course has been indicated by the authors in their preface. It can, however, be confidently asserted that this book should be read by all who intend to make a serious study of mathematics, either before or after they leave school. The authors have promised us a companion volume, entitled *Advanced Algebra*, in which the subject will be developed further along the lines of honours courses in the universities. The publication of this work will be awaited with eager anticipation. N. R. C. D.

Lectures on College Algebra. By S. B. DANDEKAR. Pp. xii, 402. Price: 3s. in India, 5s. elsewhere. 1936. (Vinayak and Co., Indore City)

In his introduction the author states that this book is intended chiefly for Intermediate students at Indian universities. It may prove to be of value to such classes of students, but it is unlikely to meet the needs of English schoolboys. The ground covered includes Ratio and Proportion, Complex Numbers, the Theory of Quadratics, Progressions, Permutations and Combinations, the Binomial Theorem, the Exponential Theorem, Indeterminate Equations (1st degree), Simultaneous Quadratics, Partial Fractions, and Determinants. Most of the examples are taken from the Matriculation or other examinations for Indian universities, or else from the works of Bhaskara. For the most part they are quite elementary. The author has been unfortunate in his publishers, for the book is disgracefully printed, and there are innumerable misprints.

N. R. C. D.

Functions of Real Variables. By W. F. OSGOOD. Pp. xii, 399. \$4. 1936. (University Press, Peiping)

Functions of a Complex Variable. By W. F. OSGOOD. Pp. viii, 257. \$3. 1936. (University Press, Peiping)

Osgood's *Funktionentheorie* is world-famous, and I hope that recent events in China will not prevent these more elementary books from becoming well known, for they make a very readable course in analysis and cover a well selected range. They are based on lectures given by the author at the National University of Peking in 1934-35 and presuppose a course of advanced calculus. In the preface to the first of these two books the author says " the Theory of Functions is a habit of thought, not a set of rules ". He has given us books which show us the methods of analysis in their development and in some of their applications. He says " the clearer the presentation in a text book is, the worse for the student who would rely on *reading* ". Certainly this does not mean that he has aimed at obscurity (at least judging by the result); he has in both books frequently left details to be filled in, giving hints for doing it, and sometimes he has suggested other possible methods of proof.

The book on real variables begins with a chapter on convergence of series, which contains the important tests for absolute convergence and the theorem on convergence of alternating series of decreasing terms. The second chapter gives a detailed account of Dedekind's construction of real numbers from cardinal numbers; here assumptions made in the first chapter are justified. This is perhaps the place to point out that the English reader will find some unusual terminology, *e.g.* the term " irrational number " does not mean a real number which is not rational, but a Dedekind section which is to become a real number by associating with it the definitions of addition, etc.

The third chapter gives the elementary ideas of sets of points and their application to the definition and fundamental properties of limits and continuous functions. Unfortunately the *terminology* does not distinguish sufficiently between bounds and limits, for the term " lower limit " is used to denote the (exact) lower bound of a set of points or of values of a function. No confusion is caused in the book itself because the ideas " $\underline{\lim}$ " and " $\overline{\lim}$ ", are not introduced, but surely no one should read only one book on any subject.

The proof of the theorem on p. 93, that from an infinite set M a subset E, which is an isolated set, can be extracted, is incorrect. The reader should consider the case in which $M=R$, the set of the rational points, with the selection rule that from any subset the point to be taken is the first in an arrangement of R in a given progression. The set E then constructed is

identical with R. When the difficulty is seen, so are the lines for a correct proof.

The next chapter explains the fundamental properties of functions which have a derivative, implicit functions, and solution of equations. It is good to find a proof of the formula $\frac{dw}{dt}=\frac{dw}{dx}\cdot\frac{dx}{dt}$ which holds even at points t_0 in whose neighbourhood $x=x_0$ infinitely often. The existence of the derivative $f_y(x, y)$ is part of the hypothesis of the implicit function theorem for $f(x, y)=0$, and nothing is said to suggest that wider conditions give a less complicated proof. There is no essential difference between the theory of functions of one and of several real variables, and this is shown by treating together corresponding problems, *e.g.* the implicit function theorem for $f(x, y)=0$ is followed by the conditions for the solubility of p equations

$$F(u_1, \dots u_p;\ x_1, \dots x_n)=0$$

for $u_1, \dots u_p$ in terms of $x_1, \dots x_n$.

After a clear chapter on uniform convergence, the theory so far set up is applied to establish properties of the elementary functions. The starting points are that $\sin x$ and $\cos x$ are solutions of the equation $y''+y=0$ and $\log x=\int_1^x \frac{dt}{t}$. The method of beginning from the exponential series is sketched as a possible alternative development.

Next is a chapter on algebraic transformations of series. These mostly depend on taking various methods of summing absolutely convergent double series (incidentally these are termed convergent, no mention being made of the Pringsheim sum, and the sum or "value" of a double series is not explicitly defined).

After this there is an excellent introductory account of Fourier series, of course of Riemann-integrable functions. The Gibbs Effect is very nicely illustrated though there is no *clear* statement of what it is, and the materials for the final step of the illustration are buried in a paragraph headed "Remark". The result that the Fourier coefficients of a function form a null sequence is set as an example, but its importance is well shown, though never stated, in this and later parts of the book.

We next have an account of properties of various types of integral; in particular of integrals depending on parameters. The properties considered mostly involve double limit problems. The recognition of double limit problems and what they involve is made quite clear. The treatment given here can be recommended especially to any who find such questions difficult. The reader should note that Duhamel's theorem on p. 301 is not quite correct; either, as is assumed in the proof, the α's should be stated to be positive, or it should be assumed that $\Sigma\,|\,\alpha\,|$ is bounded.

The general theory is now applied to give short accounts of the Γ-function * and of Fourier's Integral. It is good to find the latter included in an elementary book.

The final chapter is on ordinary and partial differential equations (total differential equations are not considered but that name is given to a set of simultaneous equations of the form $\frac{dx}{x}=\frac{dy}{y}=\frac{dt}{z}=\dots$). Knowledge of elementary methods of integration of ordinary equations is taken for granted. The emphasis is on existence theorems. Their importance is well brought out, and it is emphasised that the solution found by an elementary method can

* Graphs of $\Gamma(x)$ and $\Gamma'(x)/\Gamma(x)$ are given.

only be shown to be the complete solution by means of the appropriate existence theorem. Incidentally a footnote in the second book points out that the assertion that the orthogonal trajectories of a coaxal system of circles are circles of the conjugate coaxal system involves such a theorem. The solution of first order partial differential equations, which concludes the chapter and the book, brings out the value of some of the elaborations of the fundamental existence theorem for ordinary equations and gives a clear idea of the meaning of the method of solution. One finishes reading the book wishing for more, but not like Oliver.

The other book is about the methods of complex variable theory and contains hardly anything about particular functions; when these appear it is merely as illustrations. In many books a great deal of space is given to evaluations of definite integrals by contour integration, but here only one such integral is evaluated in the text and only one example of it is set. This allows the book to give a steady development of the theory. The student is not led into tempting side-tracks or valuable offshoots, though some of these are indicated.

The book begins with the fundamental properties of complex numbers treated as ordered pairs of real numbers, and then goes on to explain the ideas of continuity, differentiability and regularity (the terminology used, however, is that a function having a derivative at all points of a domain is called " analytic " there instead of regular or holomorphic). This leads on to the idea of conformal representation. I am sorry that in connection with the Cauchy-Riemann equations and conformal mapping of small neighbourhoods no reference is given to the Looman-Menchoff work. Some particular conformal maps are studied, and then, in greater detail, some geometry of inversion and the bilinear transformation $w=(az+b)/(cz+d)$. I am glad that the distinction between the complex and projective planes is brought out. Some examples are set to emphasise this; one is to show that in the complex plane a parabola has a cusp at infinity. Conformal mapping leads to the idea of a Riemann surface by considering the complete correspondence set up by a relation such as $w=z^2$. The meaning of " branch of a function " is carefully explained, the behaviour of some special muliform functions is given and their Riemann surfaces are determined.

The next section of the book deals with Cauchy's theorem and its applications. I am sorry that hardly any indication is given that there are topological difficulties in a complete proof of Cauchy's theorem. These however would not naturally arise as only fairly simple boundaries are considered. The proof is by Green's theorem. Isolated singularities are rightly treated directly and the expansion about a pole is found without making use of Laurent's theorem. This comes later and the name " Laurent expansion " is restricted to the case of an isolated essential singularity. Analytic continuation is carefully explained, and is applied to establish the addition theorems of the Jacobian elliptic functions.

In this section I was surprised to find that the author had overlooked an important point. Darboux' theorem that " if $f(z)$ is regular in a domain D bounded by a simple closed curve C and is continuous in $D+C$, and if the image of C by $w=f(z)$ is a simple closed curve Γ, then $w=f(z)$ gives a conformal map of D on the interior of Γ", needs additional conditions if it is to be extended to unbounded domains. This is not pointed out, and, after Darboux' theorem is proved, it is applied to show that

$$w=\int_0^z \frac{dt}{\sqrt{\{(1-t^2)(1-k^2t^2)\}}}\ (0<k<1)$$

maps the upper half of the z-plane on a rectangle. The argument given is incomplete because as it stands it would apply equally to

$$w=\int_0^{z^3}\frac{dt}{\sqrt{\{(1-t^2)(1-k^2t^2)\}}}\ (0 < k < 1).$$

One method of completing the argument is to show that $(4K, 2iK')$ is a primitive pair of periods of sn z.

The final section gives the theory of the logarithmic potential developed independently of and compared with the preceding complex variable theory. It is developed to lead to a final chapter on conformal representation, and to give one method of proving existence theorems for that theory.

These two books will be very stimulating to the student. Each contains a good number of interesting examples which should not be neglected.

The University of Peking Press are to be congratulated on the printing, which gives the books a good general appearance. There are a few misprints and one unfortunate setting out of a formula; the last formula on p. 249 (R.V.) cannot be read without turning over the page. Most of the misprints will cause no difficulty. The only ones worth pointing out are: (i) in R.V. p. 245, line 3, the reference should be to " 8 "; (ii) in C.V. p. 131, in the statement of the lemma " n " should be " a_n "; and (iii) in C.V. p. 163, the integrand in Theorem 4 should be "$f'(z)/f(z)$". R. C.

Sur les fonctions d'une variable complexe représentables par des séries de polynomes. By M. Lavrentieff. Pp. 62. 15 fr. 1936. Actualités scientifiques et industrielles, 441; la théorie des fonctions, V. (Hermann, Paris)

One of the first successes of the modern theory of real functions was the solution by Baire of the problem of the characterisation of those functions of a real variable which could be represented as the limit of a convergent sequence of polynomials, or, what is the same thing, in virtue of the classical result of Weierstrass, as the limit of a convergent series of continuous functions. Such functions are not necessarily continuous everywhere, but cannot be very violently discontinuous, and are, in fact, characterised by the property of being at most point-wise discontinuous on every perfect set.

It is with similar problems for functions of a complex variable that Lavrentieff is concerned. These problems were first stated by Montel (1905) and have been discussed in the book of Walsh, *Interpolation and Approximation*, recently reviewed. Besides the usual apparatus of complex variable theory—the topology of the plane, Runge's Theorem, the Maximum Modulus Principle, Normal Families and Conformal Representation—Lavrentieff requires the Lebesgue Theory of Measure and in particular such theorems as those of Baire, Fatou and Egoroff. These are handled with that facility which we have come to expect from the Soviet mathematicians, and lead to many deep and interesting results. Amongst these we notice the following theorem:

> *Each function defined and continuous on a closed set F, nowhere dense in the plane and not separating it, can be represented on this set as the (uniform) limit of a sequence of polynomials,*

which is a wide generalization of the earlier result when F is a simple Jordan arc, which is itself an extension of that of Weierstrass which is the case when F is a linear segment.

Although this tract is obviously not a book for the amateur it will be welcomed by all those interested in the field between real and complex variable theory, and these will be grateful to all concerned in making the work of Lavrentieff and his colleagues more accessible. J. T.

Introduction à la théorie des fonctions de variables réelles. I, II. By A. Denjoy. Pp. 55, 57. 12 fr. each. 1937. Actualités scientifiques et industrielles, 451, 452 ; ensembles et fonctions, I, II. (Hermann, Paris)

The section of the Actualités on Ensembles et Fonctions will be edited by Denjoy, who has himself written the first two articles. These contain a survey of the Theory of Functions of Real Variables, and are addressed, among others, to young mathematicians who are looking for subjects for advanced study or research. This theory has a most excellent advocate in Denjoy, who is, at last, after some thirty years of very active research, giving the benefits of his experience to a wider public.

These books, supplemented by Fréchet's article " L'Arithmétique de l'Infini " (No. 144 in the same series), will provide a very valuable guide to the two volumes of Hobson, the *Monografie Matematyczne,* and the other more elaborate accounts of Real Variable Theory.

Denjoy begins with an historical sketch and goes on to define, illustrate and explain various fundamental concepts. After statements of the more important theorems, Denjoy gives some indications of the directions of current research, but without references—doubtless we shall find these in the later articles in this section. The difficulties of deciding the content of the theory have been overcome successfully, although it may be that the English reader might have expected some account of Transforms and less about Quasi-analytic functions.

The actual chapter headings are as follows :

I. Aperçu historique. Géométrie des ensembles cartésiens. Fonctions. Continuité et convergence. Dérivation.

II. Intégration. Séries trigonométriques. Fonctions quasi-analytiques. Fonctionnelles et fonctions d'ensemble.

J. T.

L'Emploi des Observations Statistiques—Méthodes d'Estimation. By Georges Darmois. Pp. 29. 10 fr. 1936. Actualités scientifiques et industrielles, 356 ; statistique mathématique, I. (Hermann, Paris)

This appears to be the first tract in the section " Statistique Mathématique " of a general series of monographs on science published under the heading " Actualités Scientifiques et Industrielles ". The author is concerned to present those general ideas on the subject of estimation, *i.e.* the determination of the best values for the parameters of an assumed probability law from the observations provided by a sample of data, which are due to R. A. Fisher, having been published by him in the *Philosophical Transactions of the Royal Society* in 1921, and further elaborated in more recent papers. These ideas are so familiar that there is no need to detail them here. Suffice to say that the author, in four sections of this short work, has brought up most of the points with his own mathematical commentary, and has indicated what propositions have and have not, in his opinion, been demonstrated with complete rigour. He underlines the very great importance, in the theory of mathematical statistics, of these very fundamental researches of R. A. Fisher, and illustrates in a number of cases.

J. W.

Le Baccara. By Georges Le Myre. Pp. 204. 12 fr. 1935. (Hermann, Paris)

In England the playing of Baccarat under any form is illegal, and therefore we, being all good citizens, know nothing about it. However, it is fortunate for the reviewer that the book is written so clearly that it is possible for one to understand the problems in probability which arise from the game. It

would seem to be a game invented by Communists for the entertainment of the aristocracy, because all the court cards, as well as ten, are considered of no value. The important card being " nine ", which may arise itself or from two cards 7 and 2, 6 and 3, etc.

The author describes two forms of the game: Le Baccara chemin de fer and Le Baccara en banque, the former being the usual game played in France, and the second only played in red-hot gambling dens. As the " punter " has the choice of demanding another card from the " banker ", if he fails to obtain 9 in the first two dealt to him, certain varieties of play arise from this choice, and this the author has illustrated by taking the play of four players to whom he gives the characteristic names of M. L'enfant, M. Lesimple, M. Lefort, M. Letireur.

M. L'enfant plays as you may say " any old how ", and therefore is dismissed as beyond the calculus of probabilities; the play of the others is analysed in detail and the expectations estimated. Satisfaction has also been given to those curious people who prefer their statistics in diagrams (such as circles with blackened out portions) instead of in figures. At the end, some of the important points are summarised, certain rules being put in doggerel verses. The rules of play issued by a certain casino are given and occupy 11 pages; there is also a 2-page Bibliography and a Table of Contents.

Those who are familiar with the *Grammont Memoirs* will recognise the game played by the Chevalier against Count de Cameran when the latter held nothing but tens or court cards, and they will admire the foresight of the Chevalier in recommending his friend Matta to bring up a detachment of foot to match the horsemen of Cameran so that if any dispute arose about the cards it would be possible to determine the just cause. Anyone who collects books about problems in probability should add this work to his collection. W. S.

Elements of Probability. By H. Levy and L. Roth. Pp. x, 200. 15s. 1936 (Oxford, Clarendon Press)

During the present century great activity has been shown in investigations of various aspects of the theory of probability. The present work is the first elementary text-book to deal with many of these modern developments. Chapter I (Historical Introduction) covers the period from the first recorded insurance transaction (324 B.C.) to the present time. It concludes by declaring that a new synthesis is needed, like that accomplished by Laplace in his day. At present we have isolated groups of statistical investigations concerning insurance, production, social problems, genetics, quantum mechanics, and mathematical logic. The authors consider that the efforts towards unification based upon the view that probability is an extended branch of logic, instead of an actual and vital part of scientific progress, must necessarily fail.

Chapter II (The Scope of Probability) will appeal to students of logic, philosophy, and scientific method as well as to mathematicians. It divides the subject into three fields of study, all in some way related, and each a partial approach to the general problem:

(1) a mathematical theory of arrangements (without reference to chance),

(2) the observed frequency of actual occurrences (recording past events),

(3) the psychological expectation of a participant (anticipating the future).

In connection with (1), *mathematical probability* is defined in what the ordinary reader may consider a rather surprising manner. In its simplified form (p. 49, in Chapter IV) this runs: *If there is a class of* N *letters containing* n *letters* a, *then the probability of a letter, specified as belonging to the class* N, *being a letter* a *is* n/N. It will be observed that the term *equally likely* does

not occur; the authors regard its introduction into a mathematical definition as a confusion of (3) with (1). Similarly, to use the term *equally frequent* would be to confuse (2) with (1). What pertains to (2) is *Statistical Probability*, defined as the ratio of the number in a certain subclass of events to the number in the whole class, for instance, the ratio of the number of fatal traffic accidents to the total number of traffic accidents, in a given area, since a given date. Clearly statistical probability in general varies with the time, whereas mathematical probability is necessarily constant. The authors say that *a priori* probability is a form of statistical probability, but from the two examples given it is not clear whether it is a rough qualitative approximation, such as the estimation of the probability of traffic accidents as greatest in the rush hours, or a very precise numerical form, as for heads and tails, based on very extensive general experience.

After the very interesting pages in which the authors give their own views on the nature of probability, we come to a devastating criticism of the views of other writers. Jeffreys' axioms, which endeavour to give a numerical measure of psychological expectation, are declared to be merely a verbal artifice to conceal a fallacy, implying an elaborately detailed knowledge of psychological processes and their measurable qualities, for which, as a matter of fact, no data exist. As for the *Principle of Insufficient Reason*, "to adopt this standpoint is to deny the whole basis of science. Science is based upon knowledge, if only partial, and nothing whatsoever can be built on ignorance. . . ." Bernoulli's definition of probability, as the measure of the strength of our expectation of a future event, is declared to belong to (3), *i.e.* to psychology, though his calculations belong to (1), *i.e.* to the theory of arrangements. Laplace's definition, containing the terms *equally possible* and *equally undecided*, is considered to be a confusion between at least two of the three aspects, and J. S. Mill's comments on Laplace's definition to make this confusion complete. Coolidge attempts to base the subject on two empirical assumptions, of which the first is, roughly, that the relative frequency of an event will approach a definite limit as the number of trials increases indefinitely, and the second is that the probability is equal to the ratio of the number of favourable ways to the total number of *equally likely* cases. The authors' comment is that the first assumption is meaningless, not justifiable by any mathematical definition of a limit, and is an effort to abolish a vital distinction between two fundamentally different concepts, while the second is either an appeal to subjective psychology or a mere begging of the question. [The authors do not mention Von Kries' *Principle of Cogent Reason*, which takes events as equally likely only when, after careful examination, they appear to be similar in all essential respects. In the reviewers' opinion this can be applied, at least approximately, to problems concerning coins, dice, and cards, and affords some justification to the unduly ridiculed term *equally likely*.] Mises' theory of *Collectives*, *i.e.* of sequences fulfilling a limit condition and also a *Principle of Disorder*, is treated rather more gently, and the question is left open whether sequences satisfying both conditions occur never, or hardly ever.

On reaching the end of Chapter II the reader may feel that at last all confusion has been cleared away. (This impression should last until p. 58 is reached.) To meet the needs of the definition of mathematical probability, Chapter III (The Theory of Arrangements) gives an elementary treatment of permutations, combinations, the binomial and the multinomial theorems. Most of this could have been found in school textbooks of algebra, but this chapter and the next (Elementary Theorems on Mathematical Probability) are included in the hope (perhaps unduly optimistic) of making them suitable for non-mathematical students. But such students (and even others) may

easily be confused by the unfamiliar wording adopted in order to eliminate psychological terms. In particular the wording of the theorem on the multiplication of probabilities may obscure the essential distinction between the two cases of independent and dependent events. Perhaps even the authors themselves have overlooked this distinction, for the solutions to the worked examples 1 and 5 on p. 59 in Chapter V seem to neglect it, and consequently to be incorrect. For example, in calculating the probability that a hand of 13 cards should contain 4 aces, it seems to be assumed that because the probability of drawing one ace from 52 cards is $\frac{4}{52}$, the probability of drawing two in succession is the square of this fraction. Actually, of course, it is $\frac{4}{52} \times \frac{3}{51}$, since $\frac{3}{51}$ is the probability of drawing a second ace from a pack with one ace removed.

There are some other points in Chapter V which puzzled the reviewers. The chapter is headed Bernoulli's Theorem, but it appears to be mainly direct deductions from the binomial theorem. (What most writers call Bernoulli's Theorem is given later on p. 142, and is called Bernoulli's Limit Theorem.) The treatment appears to be restricted to the authors' first aspect of the subject; in fact it is asserted on p. 102 that this restriction applies to all the preceding pages. Yet a footnote on p. 58 tells us to interpret the probability in Bernoulli's theorem by reference to the discussion on *a priori* probability. On p. 60, under the heading *Note on Terminology*, the whole basis of the book seems to be suddenly abandoned. " At this stage, therefore, we propose to discard the restrictions hitherto imposed on our terminology ", for though to maintain them will " certainly avoid the error of confusing psychological expectation with mathematical probability ", yet it will " also lose the possibility of applying the theory to actual cases ". After this they discuss snipers who kill, " on the average ", once in three shots, and ask how many aces are " most likely " in a hand of 13 cards. All the ideals of clarity, on which such stress is laid in Chapter II, have to be given up, as apparently they cannot be applied in practice. The authors have merely added one more instance to support the dictum that no theory of probability is both logical and applicable. The last part of Chapter V deals with Stirling's theorem and the Normal Law.

Chapter VI (Extension to Continuous Distributions) deals chiefly with geometrical probability, but there is also a valuable application of a well-known general theorem to traffic and other accidents. Chapter VII, dealing, like Chapter III, with The Theory of Arrangements, is similar to parts of Whitworth's *Choice and Chance* (long out of print). The last two chapters deal with statistics and scientific inference. Chapter VIII (The Empirical Theory of Distributions) introduces the terms mean, median, mode, and standard deviation, and then goes on to Tchebycheff's theorem, the Normal Law (more simply than in Chapter V) and Poisson distributions. Chapter IX (The Use of Probability in Scientific Induction) opens with general remarks on sampling, which lead to rather complicated finite difference equations. From these unexpectedly emerges the celebrated (or notorious) Bayes' theorem, which has been the subject of so much controversy. The authors' mode of derivation is interesting, but difficult to grasp, and perhaps it would have been better if the theorem had been first obtained by the usual method. After an extension of sampling theory to continuous distributions we come to Fisher's method of Maximum Likelihood. The chapter concludes with a discussion of curve fitting, regression, correlation, and tests of significance (not all consistent with the principles correctly laid down in the earlier chapters). An appendix

gives a table of the Error Function. There is an index, but the answers to the unworked examples are not given. Some of these examples are easy, but others may puzzle even capable students.

E. C. FIELLER.
H. T. H. PIAGGIO.

Calcul des Probabilités. By J.-B. POMEY. Pp. iv, 87. 25 francs. 1936. (Gauthier-Villars)

This slim volume is a record of the author's lectures at the Higher School of Electricity in Paris. In several respects the method of exposition is more English than French. Instead of starting with abstract definitions, ideas and theorems are introduced informally by the aid of simple examples and then generalised. Philosophical difficulties are avoided by regarding the notion of *equally probable cases* as an abstract conception as impossible to realise in practice as the notion of points in geometry. Those who apply the subject must decide for themselves what cases they will consider as equally probable. A problem in probability is not determinate until these cases have been specified.

The book proceeds rapidly, and the author's talent for compression enables him to deal with a great deal of matter in a few pages. After the usual account of games of chance there is a short section on Bayes' theorem in its simplest form (without reference to its use or misuse in scientific inference), followed by the Normal Law, Poisson's distribution (with an application to the scintillations of a radioactive substance), and an unusually careful discussion of geometrical probabilities. There is a treatment of probability distributions based on a graphical method of linking them up with problems in statics on the distribution of mass in a lamina of variable density. Then follow eight pages on a telephony problem to determine the number of lines that should be provided to serve a given number of subscribers, and twelve pages on the kinetic theory of gases. An appendix contains a proof of Stirling's theorem.

The book is a happy combination of English interest in examples and physical applications with French logic, conciseness, and clarity.

E. C. F.
H. T. H. P.

Nouveaux Éléments d'Analyse, I. By A. BUHL. Pp. vii, 204. 60 fr. 1937. (Gauthier-Villars)

This book contains a chapter on sets of points and related subjects; two chapters on multiple integrals and their geometrical applications; chapters on the theory of surfaces, continuous groups, tensor calculus and a final chapter on partial differential equations and some of their physical applications. Its main object is to show how these topics are related to each other by means of a few central ideas, notably Stokes' theorem and its generalizations.

Except in the first chapter, which seems to me rather weak and purposeless, the presentation is purely formal. A characteristic feature is the use of symbols which are subject to non-commutative multiplication. For example, in the theory of skew-symmetric differential forms and their exterior derivatives many writers, particularly those of the French school, have used $dx_1, \ldots, dx_n$ as symbols which are subject to the ordinary laws of addition and multiplication, except that $dx_i dx_j = -dx_j dx_i$. Here this formalism is used from the first in discussing double integrals. From $dxdy = -dydx$ it follows that $dx^2 = 0$ and, if x and y are functions of u and v $(dudv = -dvdu)$, the relation

$$dx\,dy = \frac{\partial(x, y)}{\partial(u, v)}\,du\,dv$$

follows automatically. Similar methods are used throughout and the result is a neat account of the subjects considered.

Relative to its size I think the book contains too many isolated fragments which are little more than indications of how the main ideas and methods can be applied to various branches of mathematics and physics. As it stands it is in many ways suggestive, but, considering how much is left out (for example, all except purely formal existence theorems), I think the main topics should have been treated more thoroughly and carried further. J. H. C. W.

Origins of Clerk Maxwell's Electric Ideas as described in Familiar Letters to William Thomson. Edited by Sir JOSEPH LARMOR. Pp. 56. 3s. 6d. 37. (Cambridge)

In the preface to his *Treatise on Electricity and Magnetism* Maxwell makes the remark: "It is of great advantage to the student of any subject to read the original memoirs on that subject, for science is always most completely assimilated when it is in the nascent state." This volume of letters from Maxwell to (Sir) William Thomson exhibits what may be termed the pre-nascent state of Maxwell's theory of the electromagnetic field. It is interesting to trace the growth of the conceptions through these letters to the construction of the formal theory in the published memoirs and then to the final form when "the scaffolding is pulled down" in the *Treatise.*

The letters themselves are spontaneous effusions, written without self-consciousness, occasionally rambling, and covering personal matters as well as scientific. But they exhibit entire confidence in the writer's own powers to attack the problems involved, and a set purpose to formulate a clear and satisfactory theory of the electromagnetic field.

The first letter is under date 20th February, 1854, within a few weeks of his graduation. It contains a series of questions. "I have begun to think of reading. . . . Suppose a man to have a popular knowledge of electrical show experiments and a little antipathy to Murphy's Electricity, how ought he to proceed in reading and working so as to get a little insight into the subject which may be of use in further reading?" The reply and Maxwell's "reading and working" bore fruit rapidly. For by 13th November of the same year he writes that he had "been rewarded of late by finding the whole mass of confusion beginning to clear up under the influence of a few simple ideas. . . ." ". . . Now I thought that as every current generated magnetic lines and was acted on in a manner determined by the lines through which it passed that something might be done by considering 'magnetic polarization' as a property of a 'magnetic field' or space and developing the geometrical ideas according to this view." The idea of polarisation is then defined formally and applied mathematically to electromotive forces, induction in soft iron, etc.

By 13th September, 1855, Maxwell had prepared a plan for the unification of electrodynamics. He visualises a system "of purely geometrical truths embodied in geometrical conceptions of lines, surfaces, etc.", which may "*afterwards* be applied to Electricity, Heat or Magnetism or Galvanism". The truths consist of the properties of the potential, lines of force and equipotential surfaces, and the geometrical aspect of electrical image systems. These are to be applied to Faraday's notion of an *electrotonic* state. "One thing it succeeds in, it reduces to one principle not only the attraction of currents and the induction of currents, but also the attraction of electrified bodies without any new assumption."

This letter might be said to contain an explicit statement of the aim of Maxwell's life-work.

A letter of great interest is that of 10th December, 1861, in which is announced

to Thomson the discovery of the electromagnetic theory of light. The verification of the theory depended upon the value of the ratio of the electromagnetic and electrostatic units of electricity, and upon the velocity of light, neither of which were too accurately known at the time. For the first Maxwell had Kohlrausch and Weber's result of 193,088 miles per hour; for the second values were known from Fizeau's experiment or from the constant of aberration, assuming a knowledge of the dimensions of the earth's orbit. In a letter to Faraday on 19th October, 1861, nearly two months prior to the letter to Thomson, Maxwell calmly announced his discovery. "... I have determined the velocity of propagation of (electrical) vibrations. The result is 193,088 miles per second. Fizeau has determined the velocity of light as 193,118 miles per second by direct experiment." This must have seemed a most remarkable agreement, the difference being only 30 out of nearly 200,000. Unfortunately the velocity of light quoted is not Fizeau's figure. It is taken from Galbraith and Haughton's *Manual of Astronomy*, p. 53, probably the only book at hand at the moment containing a value of the velocity. It must therefore have been rather disappointing in writing later to Thomson to have to put the result

Velocity of light	192,500 by aberration
	195,777 by Fizeau
Miles per second	193,118 Galbraith and Haughton's statement of Fizeau's result.

Neither the aberration value nor Fizeau's own value agree nearly as well with the electrical constant as did the Galbraith and Haughton figure. It is therefore interesting to note how Maxwell states his conclusion. In the same letter to Thomson he puts it "... so I think I have reason to believe that the magnetic and luminiferous media are identical". In his published paper *On Physical Lines of Force* (1862) he quotes Fizeau's result and relegates Galbraith and Haughton to a footnote; and his conclusion is "we can scarcely avoid the inference that light consists in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena". Finally in his *Dynamical Theory of the Electromagnetic Field* (1864) there is included the further value for the velocity of light found by Foucault in 1862 at 185,000 miles per second. This again does not improve the agreement. There is however by now a stronger note of conviction. "The agreement of the results seems to show that light and magnetism are affections of the same substance, and that light is an electromagnetic disturbance propagated through the field according to electromagnetic laws."

A letter of interest to teachers of mechanics is that of 17th December, 1856, when Maxwell held the Chair of Natural Philosophy at Marischal College, Aberdeen. Here he gives some notes on his method of teaching. "My special study is Elementary Mechanics and just at present parabolic motion." One is sorry the letter is not longer and more in detail.

The volume presents material for a detailed study of the growth of the scientific conceptions of a man of genius. It may be regarded a supplement to Campbell and Garnett's *Life* or to the *Commemoration Volume* (1931), and is an additional memorial to "one who has enriched the inheritance left by Newton and has consolidated the work of Faraday". G. R. G.

Principles of Quantum Mechanics. By Alfred Landé. Pp. xii, 119. 7s. 6d. 1937. (Cambridge)

In order to know anything about very small quantities of matter we have to use radiation to observe it. In order to interpret the observations we must

therefore have an adequate theory of the nature of radiation. But there are *two* such theories in current use, the wave theory and the corpuscular theory. Their application gives us two sets of *data* about the matter. The wave theory supplies data about the distribution of the matter, and the corpuscular theory about its energy and momentum. However, since each theory gives us a complete account of the radiational phenomena, it would be wrong to suppose that we can get more information about the matter by using *both* theories than by a consistent use of either theory separately. Therefore it would be illogical to use both sets of data simultaneously, and so we must regard them as complementary to each other. " The main object of quantum mechanics is to develop the direct mathematical relations between complementary data after discussing their origin and their consequences from a physical point of view " (p. 2). Such is the development presented by Professor Landé in this book.

A word must first be said about the apparent inconsistency in using the term *data*, not for the actual observations, but for their interpretation according to some theory. However I suppose all " data " about atomic phenomena must be of this sort, since the atomic phenomena themselves are really theoretical constructs. But the usefulness of having an atomic theory of matter is now almost beyond doubt.

The author begins with the standard association of a wave-length λ with a beam of particles of matter of corpuscular momentum p. The kernel of Part I of the book is the consideration of the diffraction of light by a *double ray* of matter, *i.e.* a homogeneous beam of momentum p and wave-length λ which is reflected from a wall in such a way that it returns along the same path (parallel to the x-axis, say). Interpreting the coherent scattering of the light on the wave theory, we get a *density function* $\rho(x)$ of the beam, and on the photon theory an *abundance function* $\sigma(p)$ of the momentum, " both properties accounting for the same physical activity in two different interpretations ". This last feature accounts for the title " Principle of Complementarity " for this Part. The work is then extended to a non-homogeneous beam. A mathematical relation between $\rho(x)$ and $\sigma(p)$ is then set up by means of suitably defined *density amplitudes* or *abundance amplitudes* (*probability amplitudes*) and *wave-functions*. This work suggests all the further generalisations of the theory, which, as the author is careful to point out, find their final test in the agreement of their predictions with observation. A consideration of the incoherent scattering in these experiments leads to a definition of *transition probabilities* and *matrix elements* and their interpretations.

Part II is a careful study of the " Principle of Uncertainty ".

Part III is called the " Principle of Interference ". It is concerned with what Professor Landé calls the central problem of quantum mechanics. Let $Q(q_1, q_2 \cdots ; p_1, p_2, \ldots)$ be any physical quantity defined as a real function of the coordinates $q_1, q_2, \ldots, q_n$ and momenta $p_1, p_2, \ldots, p_n$ of the system under consideration. The problem is to predict the abundance $\tau(Q)$ of various values of $Q(q_1, q_2, \cdots ; p_1, p_2, \ldots)$ in a certain experimental " set-up " characterised by a given density amplitude $\psi(q)$ or abundance amplitude $\chi(p)$. The solution is given by the *general theorem of the interference of probabilities*. This necessitates the establishment of Schrödinger's wave equation and a discussion of conjugate variables.

Part IV on the " Principle of Correspondence " sets up a formal correspondence between classical and quantum mechanics.

Part V is called the " Principle of Invariance ". It is shown that the general interference theorem is invariant with respect to a transformation from one set of conjugate variables to another. This work includes a sketch of the general transformation theory of P. Jordan.

This book supplies the best introduction I have come across to the general principles of quantum mechanics. It could and should be read by anyone with a working knowledge of elementary quantum theory who wants, as the wrapper says, to re-examine its concepts. Particularly, I venture to think, anyone who wants to be in a position fully to appreciate Dirac's standard treatise would find it invaluable. And this last feature suggests the only criticism I presume to offer, which is that Dirac's notation might have been followed. That actually adopted is not greatly different, but a complete agreement with Dirac's usage would probably have been welcomed by most readers. W. H. McCrea.

Projective Geometry. By B. C. Patterson. Pp. xiii, 276. 17s. 6d. 1937. (John Wiley and Sons, New York; Chapman and Hall)

This is a good solid introduction to projective geometry for undergraduate students. It is on the whole assumed that the reader has never come across or even heard of projective geometry before but has a good school acquaintance with euclidean geometry. The book is as readable as can be expected, the proofs are straightforward and clear, the figures numerous and admirable; I should say in fact that if a student with no knowledge of the subject wanted to read it up fairly thoroughly he could hardly find a better book for the purpose.

The logical structure is not always impeccable. Prof. Patterson avoids the difficult theory of *würfe* by defining the cross ratio metrically and proving its projective invariance in the elementary manner; and for elementary students this is doubtless the best plan; but he later emphasises that he is assuming (though he does not explain why it should be necessary to assume) that a projectivity which leaves invariant three points of a line leaves every point of it invariant, forgetting that once we have cross ratios this is not an assumption but an easy theorem. He is also a bit rocky about what we mean by saying that the " net of rationality " (harmonic chain) derived from three points of a line is everywhere dense in the line; all that he proves is that every segment *whose end points belong to the* " *net* " has internal points belonging to it.

The introduction of imaginary elements is not perfectly clear; the author's intention seems to be to use, instead of the trigonal involution which has lately been fashionable, a tetragonal involution consisting of harmonically related pairs of pairs in an ordinary elliptic involution. But he does not make clear that this is what is happening, nor how the orientation or sense is to be linked on to the involution. Another oddity is that though the focal properties of conics are treated at considerable length, after the introduction of imaginaries, no mention at all seems to be made of the imaginary foci.

Solid geometry appears only as an adjunct to plane geometry, to enable us to prove Desargues' theorem, to establish projectivities between planes perspectively and so forth. The regulus as a one-dimensional form appears, but no discussion of the quadric as such, nor of projectivities in space.

At the end of the book is a brief but admirable explanation of the projective, affine, homothetic, translation, similarity and metric groups, with their relations to each other (in the plane only) in terms of an ideal line and two absolute points (or an absolute involution) in it. Patrick Du Val.

Differential Systems. By J. M. Thomas. Pp. ix, 118. $2.00. 1937. Colloquium Publications 21. (American Mathematical Society)

The last fifteen years, that is to say, the period following the publication of Goursat's *Problème de Pfaff* and Cartan's *Invariants intégraux*, witnessed a

remarkable swing of the theory of differential equations over towards the domain of higher algebra. So much so that to study the more recent investigations into the existence of solutions calls for a knowledge first and foremost of van der Waerden's *Moderne Algebra.* The present monograph sets out to develop, and at the same time to correlate, the kindred theories of partial differential and of pfaffian systems on purely algebraical bases.

Every classical existence theorem depends upon certain restrictive hypotheses, as, for example, that the differential system under consideration is polynomial in the unknowns and their derivatives, with coefficients holomorphic in a certain domain. Hypotheses of one sort or another are inevitable ; the modern algebraical method of approach allows the assumptions to be stated in terms far more comprehensive than those of the older theory. These assumptions are justifiable when they are consistent with one another, and when the theorems deduced from them, applied to specific existence problems, prove to be no less general than the classical existence theorems.

A concise but adequate account of Grassmann algebra leads to the notion of a *differential ring,* that is, a special polynomial ring or Grassmann ring $\mathfrak{R}\,[u]$ satisfying certain differential and integral assumptions. Here $\mathfrak{R}$ represents an *integrity domain* and u represents a finite number of non-commutative *marks* $u^1 \ldots u^n$ which are a *basis* of the ring. An instance of when the assumptions are valid is found by interpreting $\mathfrak{R}$ as a set of functions having continuous second partial derivatives. Behind the theorems that follow lies the notion of a passive pfaffian system, or system having a basis belonging to $\mathfrak{R}\,[u]$ and composed of differentials. From the point of view of differential equations, the most important of the assumptions is the third integral assumption or I_3, namely, *every pfaffian system of rank* $n-1$ *in a ring of dimension* n *is passive* ; it justifies itself by containing the Cauchy existence theorem.

This may serve to indicate the trend of the book. Its scope ranges over commutative polynomial rings, the resolution of algebraic systems, algebraic differential systems, function systems and pfaffian systems. The treatment of algebraic systems is the author's own ; the methods of resolution into simpler systems in particular are striking. The power of the methods is revealed in a chapter on consistency examples which gives instances in which the assumptions are realised. Illustrative examples are relegated to the concluding chapter.

It is a book that demands, but will repay, close reading. E. L. I.

Neuere Fortschritte in den Exakten Wissenschaften. Fünf Wiener Vorträge (Dritter Zyklus). Pp. iv, 132. M. 3.60. 1936. (Deuticke, Vienna)

In the third set of public lectures at Vienna no common thread was provided for the representatives of the various exact sciences ; if the individual speakers gained by their freedom of choice, there is no doubt that the volume of essays loses in interest and significance. Even while enjoying an account of fundamental problems of physics by Heisenberg himself, a visitor for the occasion, we feel that we should have followed him with more excitement along an unfrequented footpath than along the broad highway.

The nearest approach to mathematics in this collection is naturally Prof. Menger's contribution, and this deals with advances in the exact treatment of economics. After complaining that writers on economics have a habit which bewilders mathematicians of using " therefore " and " it follows " when no trace of logical implication is intended, Prof. Menger expresses symbolically the law of diminishing returns, and shows well the advantages of representing the dependence of consumption on price and income by a surface.

Among the more recent developments which he describes is von Wiese's adaptation of ideas from the theory of aggregates: given a division of the population into a number of classes, the important question for practical life is not to which classes an individual belongs, but which classes the individual can tolerate. The non-smoker who does not object to smoking presents no problems, nor does the man or woman who is at ease in a mixed company. It is for the non-smoker who dislikes the presence of smokers that special compartments have to be provided, and it is the man who must have a feminine environment and the woman who expects to have the men to herself who cause trouble. With Prof. Menger we recognise in von Wiese's work the beginnings of a social science which will transcend classical sociology somewhat as the mathematical logic of this century transcends the logic of Aristotle.

"Once an accident, twice a coincidence, three times a habit!" Our friends at Vienna have now formed a habit of instructing and entertaining us, and we hope that this acquired characteristic will long be transmitted. E. H. N.

Five Place Tables (Decimal System). By P. WIJDENES. Pp. 168. Fl. 2.50. 1937. (Noordhoff, Groningen)

The full title of this book, including the subtitle "Logarithms of integers, logarithms and natural values of trigonometric functions in the Decimal System for each grade from 0 to 100 grades, with interpolation tables", explains generally the scope and nature of the tables included. With the explanation that a grade is one-hundredth of the quadrant or $0°{\cdot}9$, the three main tables give 5-decimal values of the following:

(1) Logarithms of numbers, 1000(1)11000.

(2) Logarithms of the four functions, sine, tangent, cotangent and cosine for the following ranges of the argument in grades:

$$0{\cdot}000(0{\cdot}001)1{\cdot}20(0{\cdot}01)98{\cdot}800(0{\cdot}001)100{\cdot}000.$$

(3) Natural values of the same four functions at an interval of 0·01 grades.

The tables of logarithms are arranged with successive values on a horizontal line in the standard manner of presentation, while the two trigonometrical tables are arranged semi-quadrantally, the tabulations for each grade being compressed into one page for most of the range. No differences are tabulated, but complete proportional part tables are given, generally on the opening required; nine pages at the end of the book are devoted to tables of proportional parts for differences from 1303 to 111, the values being the actual differences of the cotangent from 7·00 grades to 24·60 grades. The minor tables include a one-page table for the area of segments and several conversion tables for grades into degrees and radians and vice versa.

In the above summary of the contents and arrangement no attempt has been made to comment upon the fundamental question of the choice of the grade as the unit of angle. In his Preface the author claims that "the following division finds ever more frequent application", and heads his list of applications by referring to instruments in which the quadrant is divided into 100 equal parts; there can be but few of these in this country. It is now recognised that the centesimal division of the quadrant is not practical in view of the universal use of the degree for instruments of all kinds, while for theoretical work the decimal division of the degree has much in its favour.

Unfortunately, in view of the limited application of this "new" division of the quadrant, the tables themselves have little to commend them. In the trigonometrical tables, the horizontal division of the 51 lines on the page, instead of being either by blocks of five or by the Bremiker arrange-

ment, is indicated by rules surrounding the 5's and the printing of the leading figures at the 0's; since the leading figures are also printed in full when they change, such an arrangement is most confusing. New-style figures without heads and tails are used for the main tabulation, though the more easily read old-style figures are used for the proportional part tables. In addition to these general points affecting the use of the tables as a whole, the reviewer fails to appreciate the slavish adherence to five decimals, even for the cotangent of 0·01 grades; nor can he see the necessity for the provision of 9 pages of proportional parts for the interpolation of the 6-figure (but admittedly 5-decimal) cotangents between 7 and 24 grades. Surely a five-place table implies an accuracy of 1 in about 100,000 and not 5-decimal accuracy in a quantity that may have several figures in front of the decimal point! Even in the formulae for the cotangent of small angles, five decimals are given in a quantity of the order of a million, while the logarithm is given only to five places.

In view of the above remarks it is only fair to say that examination of certain samples of the tables has revealed no errors. Further, the printing and binding are good (apart from the points mentioned above), and the price is reasonable. However, the availability of 5-figure tables by Steinbrenner and of the excellent 6-figure table by Peters, in which natural values of all the six trigonometrical functions with differences are given, makes it difficult to believe that this book either meets a definite want or is any improvement on the tables already in existence. D. H. S.

Der Pythagoreische Lehrsatz. By W. Lietzmann. 5th edition. Pp. iv, 43. RM. 1.20. Abroad RM. 0.90. Mathematisch-physikalische Bibliothek, Reihe I, 3. (Teubner).

Von der Pythagoreischen Gleichung zum Fermatschen Problem. By W. Lietzmann. 5th edition. Pp. 48. RM. 1.20. Abroad RM. 0.90. Mathematisch-physikalische Bibliothek, Reihe I, 91. (Teubner)

That there exists in most people a sense of the fascination of mathematics, witness the popularity of Caliban and the late Mr. Dudeney. Excellent works of a different character such as Mr. Boon's *Companion to Elementary Mathematics* and Prof. Hogben's *Mathematics for the Million* are perhaps too expensive for the individual purse, and cover too wide a field to sustain together interest and instruction or to give other than a short glimpse of many topics. A welcome therefore should await an enlarged and bifurcated fifth edition of Dr. Lietzmann's little book, which also prompts some acid reflections on English mathematical publications in the elementary field. The number of books of beginners' geometries, algebras and arithmetics must be within sight of the number of students engaged in their study. Nor is there any appreciable difference in their subject-matter or systems. Publishers and would-be authors would do mankind a service could they stem the flood of redundant text-books and turn their efforts to something worth while after the style of Dr. Lietzmann.

These books are a stimulus to both teacher and pupil in the presentation of both subject-matter and treatment, and form a source of interest to supplement the normal course of study. The new edition of *Der Pythagoreische Lehrsatz* contains no extensive alterations. Two diagrams have been removed from the appendix and placed opposite to the relevant text. An unusual proof of the general case is included for the sake of providing a converse for Pythagoras' Theorem: yet again the author plainly shows his disdain of the *reductio ad absurdum* method. In future editions it is to be hoped that more space will be given to the general theorem: at present there is only a reference

to a work by E. Dintze. Finally—a small point—it is remarkable that Dr. Lietzmann has reached the fifth edition without noticing that in Fig. 31 not even a single triangle is necessary for the comparison of square and rectangle.

In the second volume the "glance" at Fermat's "Greater" Theorem has been amplified into a short historical and mathematical review. A discussion of irrationals is followed by a few illustrations of the application of Pythagoras' Theorem. Then comes a masterly little disquisition on Pythagorean numbers leading, of course, to Fermat and the tribulations of the Scientific Society of Göttingen.

Dr. Lietzmann is, as ever, very readable, his subject-matter full of well-contrived discussions and illuminating points of view. If a copy of the previous editions has not yet found a place in either a teacher's bookshelves or students' library, the omission should be remedied. The cost is not great and the frontispiece alone worth the money. J. E. Blamey.

Plane Trigonometry, with five place Tables. By H. A. Simmons and G. D. Gore. Pp. viii, 201, 81. 10s. 1937. (John Wiley & Sons, New York; Chapman & Hall)

On reading this book we feel inclined to echo the words in which Macaulay criticises Croker's edition of Boswell's *Life of Johnson*. But the criticism would not be entirely apt, for the book, issuing as it does from an American publishing house, is excellently printed, with clear diagrams, and attractively bound. We regret, however, that it has little else to recommend it. We do not expect startling originality in an elementary trigonometry, although the authors make some claim to it, but neither do we expect to find the subject developed along lines which have been discarded in this country for nearly half a century. Possibly, however, we are being a little harsh. It is the custom here to introduce trigonometry early, beginning with simple numerical work. If this book can be regarded as a guide (which we doubt), it would seem that American practice favours a later start and a more theoretical course.

The six ratios, together with the versed and coversed sines and the haversine, are all introduced together on p. 2. The ratios of 30°, 60°, and 45° are obtained and the formulae $\sin^2 A + \cos^2 A = 1$, etc., proved, and we are at once plunged into identities. These are necessarily either highly artificial or supremely inartistic and are sometimes both; thus on p. 9 the student is asked to evaluate $\sqrt{(\sin^{-4} 60^\circ \cos^{-6} 30^\circ \div \sin^6 60^\circ \cos^{-10} 30)}$, and others of a similar nature. It is an inevitable consequence of this line of approach that the exercises must be either trivial or much too hard. Thus in the very first set of exercises the student is asked to prove that $\cos A < \cot A$ when $0^\circ < A < 90^\circ$. The wording of some examples is both clumsy and inaccurate, *e.g.* "Verify the equations in Exercises 21-27 by using the *fact* that $A + B = 90^\circ$." (P. 18: A and B have not been previously defined; the italics are mine.) In the worked examples the left and right-hand sides of identities are simplified simultaneously until some obvious truism is reached. This is just what we tell boys *not* to do.

Chapter II deals with the solution of right-angled triangles, using three-figure tables (which are provided on pp. 22, 23). Here we find two excellent sections, namely, those on interpolation (pp. 24, 25, 26), and on approximation and degree of accuracy (pp. 32-37). The next two chapters deal with the trigonometric functions of any angle, which are treated along ordinary lines. A slight notational discrepancy occurs in the second of these. Elsewhere throughout the book 3.73 means 3 decimal 73 and 3·73 means 73×3 (the notation thus being the reverse of that adopted in England). But on p. 71 we find 2.90° being used for 180°.

From this we proceed to circular measure and the graphs of the functions. The latter are obtained both by projection and by plotting from tables, but the exercises in both these chapters are of poor quality.

The addition theorems follow, the usual geometrical proofs being given. The results are then extended to angles of any magnitute. In this particular the authors have been very careful: whenever necessary all four quadrants have been considered (*vide* pp. 70 and 83). In the chapter on logarithms which follows, a proof (quite unnecessary in a book of this nature) is given of the formula for change of base, but the method used is about as clumsy as it could well be.

And now at last (Chapter X) we come to the solution of triangles. The usual formulae are obtained, but none of the properties of triangles are given; indeed, the circumcentre and orthocentre are not mentioned anywhere in the whole book. There are no three-dimensional exercises.

The last two chapters are on the inverse functions and trigonometric equations. In the first of these we notice a further divergence from English usage, namely, in the reversal of the meanings attached to $\sin^{-1} x$ and $\mathrm{Sin}^{-1} x$. Five simple types of equations are considered in the last chapter, and it is here that the authors show that they are humourists as well as mathematicians. On p. 172 they say: "The student should now be able to prove that (*inter alia*)

$$x^2+2ax+a^2=(x+a)^2$$

and

$$x^2-a^2 \qquad =(x+a)(x-a)."$$

Well, well! We shouldn't be very surprised if he could!

Answers, index, and 81 pages of tables complete the book. The tables comprise five-figure logarithms of numbers from 10,000 to 99,999 and five-figure logarithms of functions at intervals of 1′, with special interpolation tables for dealing with angles near 0 and 90. These tables go a long way towards compensating for the defects of the earlier part of the book.

N. R. C. D.

School Certificate Algebra. By C. V. Durell. Pp. xv, 399, xxxii, xliii. 5s. 1937. (Bell)

This is an alternative version of *A New Algebra for Schools* by the same author. A conspicuous feature is the wealth and variety of the examples and illustrations. Additional examples required only by those who need extra practice, and harder examples for those who run ahead of the class, are indicated as distinct from those required by all pupils; and frequent revision exercises appear at intervals throughout the book. There are also four-figure tables of square roots, logarithms and anti-logarithms.

Part I (pp. 192) deals with the groundwork and elementary processes, directed numbers, simple and simultaneous equations, problems, formulae and graphs, the last 37 pages being devoted to tests in manipulation and revision papers.

Part II (pp. 202) completes the course so far as is required for elementary algebra in school certificate examinations, including a chapter on indices, surds and logarithms, and one on arithmetical and geometrical progressions. The last 44 pages are devoted to tests in manipulation and revision papers.

Any pupil of ordinary intelligence will find here (except perhaps in the chapter on directed numbers) all the help that he needs without any external aid, and the frequent beautifully worked-out examples will make it very easy for him to avoid the usual pitfalls. One cannot too strongly commend this book as eminently suitable in every way for the purpose intended.

On page 302 the logarithm of a number to base 10 is defined as " the power to which 10 must be raised to give the number ". The next sentence " *a logarithm is always an index* " makes the meaning quite clear ; but would it not be better to insert the words " *the index of* " before " the power "?

Chapter V deals briefly with directed numbers—briefly perhaps because the experienced author recognises that this subject generally, if not invariably, needs the living voice of the teacher. Addition and subtraction of directed numbers are illustrated by reference to the number scale. Multiplication and division might well be similarly illustrated. For instance, $-5-3(-2)$ means start at -5 and face negatively, prepared to take steps each of -2 ; then take 3 steps *backwards*. A pupil will readily construct alongside the original number scale another scale of a's, where a is (say) -2 or $-1\frac{1}{2}$. It will probably read at first $\ldots 2a, a, 0, -a, -2a \ldots$, and in order to stress the distinction between $2a$ and $-2a$ he can easily be led to make the change $\ldots +2a, +a, 0, -a, -2a \ldots$. When he thoroughly understands $p=na$, where p, n, a are all directed numbers, the two aspects of division arise from $p=?(a)$ and $p=n(?)$. Is it not more important to realise that a negative multiplier reverses the sign of the multiplicand while a positive multiplier leaves the sign of the multiplicand unchanged than that like signs give a positive sign and unlike signs a negative sign? The latter rule may very well be left until the pupil himself suggests it.

The answers to the numerous examples occupy the last 75 pages of the book.

W. J. D.

Junior Revision and Mental Tests in Arithmetic and Algebra. By R. J. Fulford. Pp. 79, 28. 1s. 6d.; without answers 1s. 1937. (University Tutorial Press)

There are five Revision Papers in Arithmetic and five in Algebra ; but chiefly the book consists of 98 short Test Papers in Mental Arithmetic and 92 in Mental Algebra, all carefully graduated and arranged under headings which indicate the subject matter. The teacher is provided with 28 pages of answers ; he should, however, himself work Test 21 in Mental Arithmetic before he reads out that £$3 \div 240 = \frac{8}{16}$ or that $1\frac{1}{4} \div \frac{3}{4} = 9$.

W. J. D.

Fundamental Geometry. By P. B. Ballard and E. R. Hamilton. Second Series, Books I, II and III. (University of London Press)

Geometry. By W. H. E. Bentley and E. W. Maynard Potts. Part One : Discovery by Drawing and Measurement. Pp. 112. 1s. 9d. 1937. (Ginn)

There has been recently increasing attention paid to the history of mathematics and its place in teaching. It is becoming more widely held that Geometry should not be presented as having always consisted of abstract problems and theorems arranged in a severely logical sequence by Euclid. Geometry existed before Euclid, and his work consists, in great part at least, of the collecting together into a definite system of the results of centuries of previous experience. Further, this experience was not abstract in character but severely practical, arising, as Dr. Ballard and Mr. Hamilton say, out of the need for " knowledge for urgent practical purposes ". Progressive abstraction has marked the development of all mathematics, until nowadays calculation of all kinds is so far from the pebbles that gave it its name that the fact that the pebbles ever existed is apt to be forgotten altogether. But the child's mind, like that of the human race, starts from the concrete and has to be introduced to the abstract gradually by the teacher.

It is with this principle in the foreground that Dr. Ballard and Mr. Hamilton

have written their *Fundamental Geometry.* Their way of teaching is the practical and experimental way. " We have made both the instruction and the exercises in this series as practical as possible, and have at the same time kept steadily before us the necessity of building up in the pupil's mind an orderly system of geometrical truths." It seems a pity, as with the first series, that solids have not been used as the starting point. There is more work with solids in this series, but they are treated as the development of plane figures, whereas the child's experience is the other way round. The books are primarily concerned to give a knowledge of space rather than to teach logical relationships. The authors are not unmindful of the latter aspect of the teaching of geometry, but they maintain that the background of spatial knowledge must be in existence in the child's mind first. " It is not a feature that can be taught in vacuo ; it must emerge naturally from the pupil's commerce with his spatial environment. Hence the historical and psychological sequence is followed in these books rather than the purely logical sequence."

How does this work out in practice? The exercises in this second series are certainly practical, though they give the impression of being less so than in the first series in the sense that more of them deal with geometrical figures and fewer with the shapes of objects in common experience. This follows the gradual move towards abstraction, but the appeal to actual things is still resorted to frequently and they are used to illustrate the new geometrical facts that are progressively introduced. But the pupil's books do not stand alone ; the teacher's books form an integral part of the course. Corresponding to each exercise they give suggestions for oral work designed to make the pupil conscious of the point that the exercise is intended to rub in. And this oral work shows again how by starting from the concrete and the practical the abstract geometrical fact can be incorporated in the pupil's store of experiences.

" Position-finding," say the authors, " by a variety of devices, bulks large in the exercises." The actual range is far wider than this might lead one to expect. The three books deal with facts and topics from angles and parallels to the theorem of Pythagoras and introduction to trigonometrical ratios. They contain, too, in suitable places, the beginnings of the ideas of logical proof which form the basis for any more advanced work in formal Geometry. They cover, in fact, the ground of that part of Geometry which the *Mathematical Association Report* describes as Stage A, for which they should form an excellent and interesting text-book.

The other book mentioned above forms a contrast to that of Messrs. Ballard and Hamilton. There is in it very little suggestion that Geometry has ever had anything to do with measuring the earth. The first third of the book is concerned with accurate drawing and measurement of lines and angles. This is certainly a necessary part of a child's geometrical equipment, but there is all the difference in the world between making it the starting point artificially imposed by the teacher and bringing it into a course as the need for it arises. Different geometrical facts are subsequently introduced, and though they are called " discoveries ", the approach is still abstract. The pupil is told that the first year's work is treated as a voyage of discovery, but the method of introducing the discoveries does not suggest any reason why they should ever have been made. The voyage is, in consequence, hardly one that will give any thrill of adventure. J. H. H.

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EXCHANGE WANTED.

An exchange for a year with an English teacher of mathematics is desired. Will anyone interested communicate with

Miss Myrtie Whitten, Hillsboro, Illinois, U.S.A.

LONDON BRANCH.

An evening meeting was held at Bedford College on Friday, 13th November, at which Dr. Taylor (Whitgift Middle School) gave some account of his research work on " The Discovery of Kepler's Laws ". He began by pointing out the value of tracing the steps leading to the discovery of the laws, for it became clear that Kepler was compelled to modify his methods and to alter his theories to accord with observations ; the necessity of the notation of the calculus and of analytical geometry was also made plain. In his first attempt to find the scheme of the universe Kepler related the distances of the planets from the sun to the radii of the spheres connected with the five regular solids. The planet Jupiter could not be brought into this scheme, and Kepler (rather than abandon his hypothesis) decided that the accuracy of the orbits of the planets might be questioned. For five years he investigated the orbit of Mars. A modification of Ptolemy's eccentric circle device gave the position of the planet fairly accurately but not the distances from the sun. Before considering the distances of Mars, Kepler invented a new method for finding the distances of the earth from the sun. In this work the fundamental law of inertia could not be used, nor was integration available, consequently various interesting pieces of trigonometrical summation had to be tackled. Ultimately Kepler modified the circular orbit, first into an oval, then into an ellipse. For an elliptic orbit the area law was verified. The third law was discovered much later, and was first tested for the satellites of Jupiter.

On Saturday, 12th December, Professor G. Temple (King's College, London) gave the presidential address on " Hamilton's Theory of Complex Number ". He began by comparing the two points of view from which complex numbers could be regarded—as vectors or as operators. A fundamental issue was here involved : namely, what was meant by the existence of mathematical entities ? Both the realist and the idealist schools agreed that constructibility was a necessary part of such an entity. The development of complex number from the vector standpoint was straightforward until multiplication was reached. For this process there was no obvious definition, and a common feature of textbooks was the sudden change from the vector to the operator outlook at this point. This sudden change was unnecessary if Hamilton's line of development was followed throughout. Professor Temple treated this in detail (and, it is hoped, will expound it in the pages of the *Gazette*) and showed how the Argand diagram representation could be obtained by introducing the special complex numbers 1 and i. Hamilton's operational treatment had useful applications in physics and mechanics—for example, in obtaining the components of velocity and acceleration in polar coordinates. The discussion which followed was very much to the point and many speakers made extremely interesting comments, indicating that the subject was full of possibilities. During the discussion Professor Temple showed the extension of Hamilton's ideas to three dimensions leading to quaternions.

C. T. Daltry, Hon. Sec.

MIDLAND BRANCH REPORT FOR 1936.

The first meeting of the year was held in the Library of the Education Department, Birmingham University, on Friday, 7th February. Mr. E. V. Smith

(King Edward's High School) opened a discussion on "The Algebra Report". His remarks led to an animated discussion in which eight other members took part.

The second meeting was held on Wednesday, 11th March, when a well-known business man, Mr. A. Perry-Keene, costs comptroller of the Austin Motor Company, gave a stimulating address entitled "The Mathematics of Time". The lecturer dealt with his subject from the point of view of the head of the costing department of a large industrial concern. After a rapid review of the evolution of man as a mathematician, he referred to the enormous growth of wealth in the British Isles since 1851. The mathematician, the engineer and the chemist were closely associated in this growth. Recently, the Austin Motor Company had been pioneers in the development of a system of accounting based on the expenditure of time-energy for each stage in the manufacture of an article. The paper, which was of an unusual character, led to considerable discussion.

The third meeting was held on Friday, 16th October. The President of the Branch (Capt. A. Jackson, King Edward's High School) chose as the title of his presidential address "Scholastic Uses of Statistics". At the outset he dealt with the compilation and display of data and then passed on to the methods of summarising and estimating the inter-relation of groups of observations. Various types of averages were noticed and measures of dispersion and coefficients of correlation were explained. To illustrate the product-moment method of estimating a degree of association, the lecturer made use of a table which he had prepared showing the relation between the ages of candidates in a School Entrance examination and the marks which they obtained for the arithmetic paper.

About 35 members accepted the invitation, extended by Mr. Perry-Keene, to visit the Austin works. Two parties were arranged, one on 4th November and the other on 5th November. The visits were thoroughly enjoyed by the members.

The last meeting of the year was held on Friday, 27th November, the address being given by Mr. M. A. Porter (King Edward's High School) on "Mathematical Puzzles". In his selection of puzzles and allied mathematical curiosities, suitable for the consideration of pupils of secondary school age, the lecturer drew on a very wide range of material. The different types noticed included geometrical conundrums, arithmetical calculations with missing figures, calculations with the figures replaced by letters, mathematical cross-word puzzles and problems involving indeterminate equations.

The next two meetings arranged are: 26th February, Miss M. Hammond (Education Department, Birmingham University) on "The bearing of certain tendencies in contemporary psychology upon the teaching of algebra"; 19th March, Mr. C. V. Durell (Winchester College) on "The balance of theorems, constructions, riders, and practical work in the teaching of elementary geometry".

R. J. Fulford, Hon. Sec.

YORKSHIRE BRANCH REPORT FOR 1936.

The Spring meeting of the Branch was held at Leeds University on Saturday, 8th February, at 3 p.m. The rule regarding junior members passed by the Association at its Annual Meeting was discussed, and it was decided to make the following additions to the rules of the Yorkshire Branch:

(i) Any student of a University may become a student member of this Branch on payment of a fee of 2s. per annum.

(ii) Any student of a University who is a junior member of the Mathematical Association may become a student member of this Branch on payment of a fee of 1s. per annum.

Mr. E. R. Clarke (Wakefield Grammar School) then presented a paper, "The subjective hazards of examinations". The paper set out to make an original contribution to the study of examinations, defining a totally new point of departure in approaching their problems. It investigated the inconsistency of the boy with his group. This inconsistency might easily be interpreted as being with himself, but it is really with his fellows: this was referred to as the subjective difficulty in examinations. Simply it amounts to discovering that what is hard for a boy may be easy for his fellows without the general ability of the boy being below that of his fellows. The results of the investigations lead to disconcerting results. A boy's score in an examination becomes, within limits, a matter of chance. In conclusion, the lecturer suggested that the uncertainty might be remedied if the school estimate of ability was trusted for a certain range on each side of the pass mark.

The Summer meeting was held at York Training College on Saturday, 16th May, at 3 p.m. Professor W. P. Milne (Leeds University) gave a paper entitled "Should mathematicians know the History of Mathematics?" The object of the paper was to open a discussion upon the whole question of the teaching of the history of mathematics and to set forth some concrete results based upon the teaching of the subject for many years in the University of Leeds. In Professor Milne's opinion a University graduate in mathematics should possess a knowledge not only of the main theorems but also of the introduction and development of the key subjects through the centuries. An interesting discussion followed and, although there was considerable difference of opinion as to the place and extent of the history of the subject in mathematical teaching, the general view was in favour of the speaker's thesis.

The Autumn meeting was held in Leeds University on Saturday, 14th November, at 3 p.m. Professor Rosenhead (Liverpool University) spoke on "Recent investigations of fluid motion in wakes". He pointed out the connection between the wake and the work which must be done to propel the obstacle through the fluid against the retarding frictional forces. The object of engineers is to design a body or system which shall produce as small a wake as possible. By means of lantern slides in which theory and experiment were contrasted, Professor Rosenhead showed in a fascinating and illuminating manner the way in which research has gone on discussing the work of Stokes, Oseen, Helmholtz and others, and giving some idea of possible future developments.

H. H. WATTS, Hon. Sec.

BOOKS RECEIVED FOR REVIEW.

E. S. Allen. *Plane trigonometry*. Pp. xii, 152. *Six-place tables*. 5th edition. Pp. xxiii, 156. Bound in one, 6s. 1936. (McGraw-Hill)

N. Alliston. *Mathematical snack bar*. Pp. vii, 155. 7s. 6d. 1936. (Heffer, Cambridge)

J. H. Shackleton Bailey. *Elementary analytical conics*. Pp. 378. 7s. 6d. 1936. (Oxford; Humphrey Milford)

P. B. Ballard and E. R. Hamilton. *Fundamental geometry*. Second series. Pupil's book II. Pp. 48. Paper, 10d.; limp cloth, 1s. 1936. (University of London Press)

W. Blaschke. *Vorlesungen über Integralgeometrie. I.* 2nd edition. Pp. ii, 60. Wrappers, RM. 3.75. 1936. Hamburger Mathematische Einzelschriften, 20. (Teubner)

O. Th. Bürklen und **F. Ringleb.** *Mathematische Formelsammlung.* 3rd edition. Pp. 272. RM. 1.62. 1936. Sammlung Göschen, 51. (Walter de Gruyter, Berlin)

F. L. Hitchcock and **C. S. Robinson.** *Differential equations in applied chemistry.* 2nd edition. Pp. viii, 120. 7s. 6d. 1936. (John Wiley & Sons; Chapman & Hall)

L. Hogben. *Mathematics for the million.* Pp. 647. 12s. 6d. 1936. (George Allen & Unwin)

E. Kähler. *Einführung in die Theorie der Systeme von Differentialgleichungen.* Pp. iv, 79. Wrappers, RM. 3. 1934. Hamburger Mathematische Einzelschriften, 16. (Teubner)

K. Kommerell. *Das Grenzgebiet der elementaren und höheren Mathematik.* Pp. viii, 249. 18s. 6d. 1936. (Koehler, Leipzig)

H. Levy and **L. Roth.** *Elements of probability.* Pp. x, 200. 15s. 1936 (Oxford)

N. F. Mott and **H. Jones.** *The theory of the properties of metals and alloys.* Pp. xiii, 326. 25s. 1936. International series of monographs on physics. (Oxford)

W. Müller. *Einführung in die Mechanik des Fluges.* Pp. viii, 115. RM. 4.80. 1936. (Jänecke, Leipzig)

R. Nevanlinna. *Eindeutige analytische Funktionen.* Pp. viii, 353. Geh. RM. 27.60; geb. RM. 29.40. 1936. Grundlehren der mathematischen Wissenschaften, 46. (Springer)

D. A. Porteous. *Pension and Widows' and Orphans' Funds.* Pp. xii, 111. 7s. 6d. 1936. (Cambridge University Press; for the Institute of Actuaries Students' Society)

G. Sarton. *The study of the history of mathematics.* Pp. 113. $1.50. 1936. (Harvard University Press)

O. Schreier und **E. Sperner.** *Einführung in die analytische Geometrie und Algebra. II.* Pp. 308. Wrappers, RM. 6. 1935. Hamburger Mathematische Einzelschriften, 19. (Teubner)

W. M. Smart. *Text-book on spherical astronomy.* 2nd edition. Pp. xii, 430. 21s. 1936. (Cambridge)

L. Sobrero. *Theorie der ebenen Elastizität.* Pp. 50. Wrappers, RM. 3. 1934. Hamburger Mathematische Einzelschriften, 17. (Teubner)

G. Thomsen. *Grundlagen der Elementargeometrie.* Pp. viii, 88. Wrappers, RM. 3.37. 1933. Hamburger Mathematische Einzelschriften, 15. (Teubner)

J.-B. Tourriol. *Electricité.* Pp. 320. 65 fr. 1937. (Gauthier-Villars)

M. J. Van Driel. *Magic squares of $(2n+1)^2$ cells.* Pp. 90. 10s. 6d. 1936. (Rider)

S. L. Whitby. *A course in mathematics for craftsmen, I.* Pp. ix, 222. 5s. 1936. (Pitman)

Classification for works on pure and applied science in the Science Museum Library. 3rd edition. Pp. 132. 5s. 1936. (Science Museum, South Kensington; H.M. Stationery Office)

Interpolation and allied tables. Reprinted from the *Nautical Almanac for* 1937. 1s. 1936. (H.M. Stationery Office)

Neuere Fortschritte in den exakten Wissenschaften. Fünf Wiener Vorträge. Dritter Zyklus. Pp. 132. RM. 3.60. 1936. (Deuticke, Vienna)

Portraits of eminent mathematicians. Portfolio I. Twelve plates, with brief biographical sketches by D. E. Smith. $3.00. 1936. (*Scripta Mathematica*; Amsterdam Avenue & 186th Street, New York)

LONDON BRANCH.

At the meeting on 23rd January Annual Business was transacted and Members' Topics discussed.

The President for 1937 is Professor Lancelot C. Hogben, whose book on *Mathematics for the Million* has aroused much interest. The Chairman is Professor H. R. Hamley of the Institute of Education. The topics discussed were the introduction of trigonometry (Mr. Styler), the balance of subjects in the first year of the secondary school course (Mr. Clark), and curve tracing in the middle school (Mr. Daltry).

At the Friday evening meeting on 19th February Mr. W. C. Fletcher spoke to an audience of some forty members and visitors on " Euclid ", dealing with congruence, parallelism, and the mensuration of solids. He suggested that it was a good logical exercise to trace the line of descent of Euclid's proposition I. 26, on congruence, and to face the difficulties (*e.g.* what was the definition of angle, or of distance) that arose. Congruence and Euclid's parallel axiom were linked by the fact that the congruence theorems were true for the surfaces of the sphere, and the pseudo-sphere—a model of which was exhibited. A series of propositions on the quadrilateral with three angles right angles was a useful introduction to this spherical geometry. Finally, Mr. Fletcher discussed the fundamental theorems on the mensuration of prisms and of pyramids. It is hoped that a report of this paper will be available for the *Gazette*.

On Saturday, 13th March, Mr. K. S. Snell of Harrow School read a paper on " The Transition from an Experimental to a more Rational Course of Mechanics ", in which he suggested that a mathematical treatment of the fundamentals, based on thorough use of vectors, was desirable for as many boys as could profit by it. Statics and dynamics should not be separated, and constant reference should be made to the historical development of mechanics. Mr. Snell went into detail in discussing gravitational forces and equivalent systems. The paper aroused vigorous discussion in which many original and useful comments were made.

C. T. Daltry, Hon. Sec.

MIDLAND BRANCH.

The Annual Meeting of the Branch was held at the Birmingham University on 26th February, 1937. The officers for the ensuing year were elected as follows: *President*, Capt. A. Jackson; *Hon. Treasurer*, Mr. F. Meixner; *Hon. Secretaries*, Miss L. E. Hardcastle, Mr. R. J. Fulford. After the Business Meeting, Miss M. Hammond, Head of the Women's Education Department, Birmingham University, read a paper on " The bearing of certain tendencies in contemporary Psychology upon the teaching of Algebra ". Miss Hammond stated that in the psychological field there were two types of theory which deserved the consideration of teachers of Algebra; the one, in which the structure of the mind is regarded as atomic or as " a wonderfully elaborate and intricate system of connections "; the other (the holoistic type), in which the mind is viewed not as a resultant or sum of elements, but as a unit working in some sense as a whole from the beginning of any process and selecting (as it works) the necessary subordinate operations.

School Algebra readily lends itself to an atomic method of treatment. In introducing new topics, some teachers insist on preliminary drill in the elements of every step in the process and separate, for purposes of study, every relation involved. Ballard's form of examination paper illustrates this atomic type of teaching. It is, however, important to notice that an atomic method of approach to a new topic is not the logical consequence of an atomic theory of mind structure. The latter provides for purposefulness in behaviour by hold-

ing that " bonds " or mental connections are selected or rejected according to their helpfulness, or otherwise, to the purpose to be achieved.

Holoistic types of psychology lead a teacher more easily to recognise the importance of giving pupils insight into the pattern of the whole, before drilling them in the separate parts. So quadratic equations can be introduced before factorization is mastered, problems before much drill in equations, statistical graphs before much time is spent on the plotting of points. Further, while a mathematician's interest may be directed to mathematical relations themselves, the interest of a child is mainly concerned with the bearing of these relations on his social and physical environment. Hence, in order that the child may appreciate a purpose in the study of algebra, the practical value of such things as formulae and statistics should be emphasized as much as possible.

QUEENSLAND BRANCH.

Fourteenth Annual Report, presented to the Annual Meeting on 3rd April, 1936.

The last Annual Meeting was held at the University on 5th April, 1935 ; the annual report and the financial statement were presented and adopted, and the officers for the ensuing year were elected. The Presidential Address by Professor Simonds was on " The Error Function ".

During the year three ordinary general meetings were held. At the first, at the University on 17th May, a paper on " Rational Right-angled Triangles " was read by Mr. J. P. McCarthy. At the second, held on 2nd August at the Boys' Grammar School, Mr. J. C. Deeney read a paper entitled " The Dawn of Geometry ". At the third, held at the University on 1st November, a paper by Miss F. I. Bourne entitled " Playing with Probability " was read to the meeting.

The number of members is 26 of whom 11 are members of the Mathematical Association. Copies of the *Mathematical Gazette* are circulated among associate members.

The statement of receipts and expenditure shows a credit balance of £4 14s. 2d. Attendance at meetings has been satisfactory, and our thanks are due to those members who supply papers for the various meetings.

J. P. McCarthy, Hon. Sec.

SYDNEY BRANCH.

Report for the Year 1936.

The Sydney branch has now 21 members and 129 associates. The Organising Committee, the formation of which was agreed to at the Annual Meeting in 1935, has met twice in 1936, and has done useful work. Plans for 1936 were made ; and the formation of a Syllabus Committee, working under the Board of Examiners, was discussed. The Executive feel that the work done by the Organising Committee has been very helpful.

Three ordinary meetings of the branch have been held during the year. At the first of these Professor T. G. Room gave an address on " The Foundations of Geometry and their relations to the teaching of Geometry in schools ". This address was much appreciated by members.

At the second meeting, an extremely interesting address was given by Miss M. J. Prater, on " Regiomontanus ". At the same meeting, a paper prepared by Messrs. Outten and Gillings was presented by Mr. Outten on the teaching of theorems involving congruence and parallel straight lines. A discussion followed, and the matter was referred to the Syllabus Committee for consideration.

At the Annual Meeting, a carefully prepared paper on "The Life and Work of J. L. Lagrange" was read by Mr. Thorne. At the same meeting, the general principles and aims underlying courses of study in mathematics suitable for pupils in the first three years of a secondary course were discussed. The discussion was introduced by Messrs. Meldrum and Turner. The subject is of special interest at present, because of the prominence given to suggested changes in secondary school organisation in New South Wales.

The officers for 1937 were elected as follows: *President:* Professor E. M. Wellish; *Joint Hon. Secretaries:* Miss E. A. West, Mr. H. J. Meldrum; *Joint Hon. Treasurers*: Mr. G. L. Nairn, Mr. G. G. Aitkin.

H. J. Meldrum.

VICTORIA BRANCH.

Report for 1936.

March: Annual Meeting and discussion of the new syllabus for Leaving Certificate Mathematics I, in the light of the first year's experience of the course, particularly with regard to the Optional Section, in connection with which the candidates for examination may present a "practical book" of projects, summaries of extensive reading, excursions into mathematical bye-paths, etc.

June: Lecture, aided by epidiascope projection of figures and photographs and models, on "Generalized Semi-regular Figures", by Mr. F. J. D. Syer.

July: Lecture by Dr. Baldwin, the Government Astronomer, on "Majority Systems of Voting".

Since the previous meeting, news of the death of Emeritus Professor E. J. Nanson had been received, and the President referred to the work of Professor Nanson, paying a high tribute "to his remarkable mathematical ability, to the soundness of his original work, and to the artistry and completeness of his style." From 1874, when he first taught Mathematics and Natural Philosophy in the University, he continued his work until 1922. In 1891 he was joined by Professor Michell, after which time Professor Nanson produced a good deal of original work. He had a wide knowledge of mathematical literature and a good mental catalogue for immediate reference to original work. His own work on determinants was of an outstanding character. In 1907 he addressed the Association on Matrices, and continued, at the request of members, for three evenings. He was an excellent bushman, and took a great interest in electoral reform. He advocated two parallel systems: proportional representation and counting of votes in the current preferential system. The Nanson system, complicated but perfected, is used by Convocation of the University of Melbourne.

September: Mr. W. B. Smith-White lectured on "Stellar Theory". At this meeting, the Hon. Secretary, Mr. J. A. Seitz, a former Rhodes Scholar and Inter-state cricketer, was congratulated on his appointment as Director of Education for the State of Victoria. His place as Chief Inspector of Secondary Schools has since been filled by Miss J. T. Flynn, also a member of the Branch.

F. J. D. Syer, Hon. Sec.

BOOKS RECEIVED FOR REVIEW.

B. B. Bagi. *The analytical geometry of conic sections*. Pp. viii, 248. Rs. 4. 12 as. 1936. (Published by the author, Gibb Town, Dharwar, India)

P. B. Ballard and **E. R. Hamilton**. *Fundamental geometry*. Second series. Pupil's book III. Limp cloth 1s. 2d., paper 1s. (1937.) (University of London Press)

S. Barnard and **J. M. Child**. *Higher Algebra*. Pp. xiv, 585. 20s. 1936. (Macmillan)

A. Buhl. *Nouveaux Éléments d'Analyse. Calcul infinitésimal. Géométrie. Physique théorique. I. Variables réelles.* Pp. vii, 204. 60 fr. 1937. (Gauthier-Villars)

J. C. Burnett. *Easy methods for the construction of magic squares.* Pp. 77. 2s. 6d. 1936. (Rider)

E. Cartan. *La Topologie des groupes de Lie.* Pp. 28. 10 fr. 1936. Actualités scientifiques et industrielles, 358 ; exposés de géométrie, VIII. (Hermann, Paris)

W. H. H. Cowles and **J. E. Thompson.** *A text-book of trigonometry for colleges and engineering schools.* Pp. x, 373. 12s. 6d. 1936. (Chapman and Hall)

L. Crosland. *A new school arithmetic.* Pp. x, 224, xxxii. 3s. 1936. (Macmillan)

L. Crosland. *Higher school revision mathematics.* With answers. Pp. viii, 164, xviii. 3s. 6d. 1937. (Macmillan)

S. B. Dandekar. *Lectures on college algebra.* Pp. xii, 402. 5s. 1936. (Vinayak & Co., Indore City)

G. Darmois. *L'emploi des observations statistiques. Méthodes d'estimation.* Pp. 29. 10 fr. 1936. Actualités scientifiques et industrielles, 356 ; statistique mathématique, I. (Hermann, Paris)

C. B. Davenport and **M. P. Ekas.** *Statistical methods in biology, medicine and psychology.* 4th edition. Pp. xii, 216. 13s. 6d. 1936. (John Wiley and Sons, New York ; Chapman and Hall)

Th. De Donder and **P. Van Rysselberghe.** *Thermodynamic theory of affinity. A book of principles.* Pp. xx, 142. 13s. 6d. 1936. (Stanford University Press ; Humphrey Milford)

C. V. Durell and **A. Robson.** *Advanced trigonometry.* 3rd edition. Pp. viii, 336. 8s. 6d. 1936. (Bell)

Sir A. S. Eddington. *Relativity theory of protons and electrons.* Pp. vi, 336. 21s. 1936. (Cambridge)

E. J. Edwards. *An illustrated historical time chart of elementary mathematics for senior and secondary schools, training colleges and universities.* Five charts, thick cardboard, varnished. 21s. 1936. (University of London Press)

R. H. Fowler. *Statistical mechanics.* 2nd edition. Pp. x, 864. 50s. 1936. (Cambridge)

M. Nicolesco. *Les fonctions polyharmoniques.* Pp. 54. 15 fr. 1936. Actualités scientifiques et industrielles, 331 ; exposés sur la théorie des fonctions, IV. (Hermann, Paris)

O. Ore. *L'algèbre abstraite.* Pp. 52. 15 fr. 1936. Actualités scientifiques et industrielles, 362 ; exposés d'analyse générale, VI. (Hermann, Paris)

Ch. Platrier. *Les axiomes de la mécanique newtonienne.* Pp. 58. 14 fr. 1936. Actualités scientifiques et industrielles, 427 ; exposés de mécanique newtonienne, I. (Hermann, Paris)

R. De Possel. *Sur la théorie mathématique des jeux de hasard et de réflexion.* Pp. 44. 10 fr. 1936. Actualités scientifiques et industrielles, 436 ; conférences du Centre Universitaire méditerranéen de Nice, I. (Hermann, Paris)

A. S. Ramsey. *Dynamics. Part II.* Pp. xi, 344. 15s. 1937. (Cambridge)

A. S. Ramsey. *Electricity and magnetism. An introduction to the mathematical theory.* Pp. xi, 267. 10s. 6d. 1937. (Cambridge)

L. A. Santaló. *Integralgeometrie. 5. Über das kinematische Mass in Raum.* Pp. 54. 18 fr. 1936. Actualités scientifiques et industrielles, 357 ; exposés de géométrie, II. (Hermann, Paris)

D. E. Smith and **J. Ginsburg.** *Numbers and numerals.* Pp. x, 52. 25 cents. Contributions of Mathematics to Civilization, 1. (Bureau of Publications, Teachers College, Columbia University, New York)

A commentary on the scientific writings of J. Willard Gibbs. Edited by F. G. Donnan and Arthur Haas. Two volumes. Pp. xxiii, 742 ; xx, 605. 45s. 1936. (Yale University Press ; Humphrey Milford)

Sotheran's Bibliotheca Chemico-Mathematica. Second supplement, Vols. I, II. Pp. xi, 1-840, 841-1396. 21s. 1937. (Henry Sotheran)

July, 1937

WANTED.

I am anxious to obtain a copy of Carr's *Synopsis of elementary results in pure and applied mathematics* (2 vols., 1880, 1886), and offer £2 2s. 0d., or exchange of modern books of approximately that value.

G. H. HARDY, Trinity College, Cambridge.

THE LIBRARY.

THE RED HOUSE, SONNING-ON-THAMES.

THE Librarian reports gifts as follows:

From Prof. **A. R. Forsyth,** to mark his second period of office as President, his treatise

Calculus of Variations - - - - - - - 1927

From Mr. **C. W. Adams,** another small collection of schoolbooks.

From Mr. **F. C. Boon,** books by J. C. Burnett and M. J. van Driel on magic squares.

From Mr. **T. A. A. Broadbent**:

E. GOURSAT Mathematical Analysis; II, 1 - - - - - 1916

Translated from French by E. R. Hedrick and O. Dunkel. *Other volumes of this translation would be welcome.*

J. TANNERY et J. MOLK

Fonctions Elliptiques; I - - - - - - 1893

To complete the set reported last December.

Sotheran's Bibliotheca Chemico-Mathematica. Second supplement (2 vols.) - - - - - - - - - - 1937

From Mr. **D. C. Fraser,** his book

Newton's Interpolation Formulas - - - - - 1927

From Mr. **J. H. Hope**:

F. WALKINGAME Arithmetic { : R. Langford} - - - - - - 1828

From Mr. **H. E. Tester,** a schoolbook and

P. PAINLEVÉ Leçons sur la Résistance des Fluides; I - - 1930

From the University of La Plata:

R. G. LOYARTE Física General; IV - - - - - - - - 1935

The following have been bought:

W. W. JOHNSON Curve Tracing - - - - - - - - - 1885

A booklet on the analytical triangle.

C. MYDORGIUS Prodromi sive Conicorum Libri quatuor - - 1641

The most important early book on geometrical conics not already in the Library.

S. A. RENSHAW The Cone and its Sections treated geometrically - 1875

This work evaded the usual channels of bibliographical publicity, but it is mentioned by Taylor.

– VOIRON Histoire de l'Astronomie, 1781-1811 - - - 1811

Designed as a continuation of Bailly's history, already in the Library.

J. H. M. WEDDERBURN

Lectures on Matrices - - - - - - - 1934

American Mathematical Society Colloquium xvii.

Bulletin des Sciences Mathématiques ; Sér. 2, 18-24 - - - 1894-1900

Filling the only gap in our run from the beginning in 1870 to 1914—two ominous dates. Unfortunately the volume for 1895 lacks the October number. The *Bulletin* survived the war, and later volumes would be welcome.

BOOKS RECEIVED FOR REVIEW.

P. B. Ballard and **E. R. Hamilton.** *Fundamental geometry.* Second series, teacher's book, I, II, III. Pp. 66, 63, 81. 2s. 3d., 2s. 3d., 2s. 9d. 1937. (University of London Press)

W. H. E. Bentley and **E. W. M. Potts.** *Geometry. I. Discovery by drawing and measurement.* Pp. 112. 1s. 9d. 1937. (Ginn.)

W. Blaschke. *Vorlesungen über Integralgeometrie. II.* Pp. ii, 61-128. Geh. RM. 3 ; geb. RM. 3.75. 1937. Hamburger mathematische Einzelschriften, 22. (Teubner)

F. C. Boon. *Puzzle papers in arithmetic.* Revised and enlarged edition. Pp. 64. 1s. 6d. 1937. (Bell)

W. G. Borchardt. *A School Certificate mechanics and hydrostatics.* Pp. xii, 391, xxxiv. 4s. 6d. 1937. (Rivingtons)

R. M. Carey. *A school algebra. III.* Pp. viii, 289-494, 1-23. 3s. 6d. 1937. (Longmans, Green)

R. M. Carey. *A school algebra. Certificate course.* Being parts of *A school algebra II and III.* 4s. 6d. 1937. (Longmans, Green)

A. Denjoy. *Introduction à la théorie des fonctions de variables réelles. I. II.* Pp. 55, 57. 12 fr. each. 1937. Actualités scientifiques et industrielles, 451, 452 ; ensembles et fonctions, I, II. (Hermann, Paris.)

G. Gamow. *Structure of atomic nuclei and nuclear transformations.* Second edition of *Constitution of atomic nuclei and radioactivity.* Pp. xii, 270. 17s. 6d. 1937. International series of monographs on physics. (Oxford)

R. Garnier. *Leçons d'Algèbre et de Géométrie. III. Élimination. Éléments de Géométrie réglée. Transformations de Lie. Applications à la Géométrie conforme.* Pp vi, 280. 80 fr. 1937. (Gauthier-Villars)

C. H. Hill and **P. G. Welford.** *Arithmetic. I. II. III.* Pp. 144, xxiv ; 145-264, xv ; 265-383, xii. Each book, with answers, 1s. 9d. ; without answers, 1s. 6d. 1937. (University Tutorial Press)

H. Jeffreys. *Scientific inference.* Reissue with additions. Pp. vii, 272. 10s. 6d. 1937. (Cambridge)

K. Knopp. *Elemente der Funktionentheorie.* Pp. 144. RM. 1.62. 1937. Sammlung Göschen, 1109. (Walter de Gruyter, Berlin)

K. Knopp. *Funktionentheorie. I. Grundlagen der allgemeinen Theorie der analytischen Funktionen.* 5th edition. Pp. 136. RM. 1.62. 1937. Sammlung Göschen, 668. (Walter de Gruyter, Berlin)

E. Landau. *Über einige neuere Fortschritte der additiven Zahlentheorie.* Pp. 94. 6s. 1937. Cambridge tracts, 35. (Cambridge)

M. Lavrentieff. *Sur les fonctions d'une variable complexe représentables par des séries de polynomes.* Pp. 62. 15 fr. 1936. Actualités scientifiques et industrielles, 441 ; la théorie des fonctions, V. (Hermann, Paris.)

T. M. MacRobert and **W. Arthur.** *Trigonometry. I. Intermediate trigonometry.* Pp. x, 206. 5s. 6d. 1937. (Methuen)

J. H. Michell and **M. H. Belz.** *The elements of mathematical analysis. I. II.* Pp. xxiv, 1-516 ; xii, 517-1087. 42s. each volume. 1937. (Macmillan)

M. Morris and **O. E. Brown.** *Analytic geometry and calculus.* Pp. x, 507. 21s. 1937. (McGraw-Hill)

W. F. Osgood. *Functions of real variables.* Pp. xii, 399. $4. 1936. (University Press, National University of Peking)

W. F. Osgood. *Functions of a complex variable.* Pp. viii, 257. $3. 1936. (University Press, National University of Peking)

C. I. Palmer and **W. L. Miser.** *College algebra.* 2nd edition. Pp. xvi, 467. 15s. 1937. (McGraw-Hill)

T. Rado. *Subharmonic functions.* Pp. v, 56. RM. 6.60. 1937. Ergebnisse der Mathematik, Band V, Heft 1. (Springer, Berlin)

R. Sauer. *Projektive Liniengeometrie.* Pp. 194. RM. 9. 1937. Göschens Lehrbücherie, 23. (Walter de Gruyter, Berlin)

F. Schilling. *Pseudosphärische hyperbolische-sphärische und elliptisch-sphärische Geometrie.* Pp. viii, 240. RM. 12. 1937. (Teubner)

G. Schulz. *Formelsammlung zur praktischen Mathematik.* Pp. 147. RM. 1. 62. 1937. Sammlung Göschen, 1110. (Walter de Gruyter, Berlin)

A. W. Siddons, K. S. Snell and **N. R. C. Dockeray.** *Further mechanics and hydrostatics.* Pp. viii, 184. 3s. 6d. 1937. (Arnold)

J. M. Thomas. *Differential systems.* Pp. ix, 118. $2. 1937. American Mathematical Society Colloquium Publications, 21. (American Mathematical Society, New York)

J. Tropfke. *Geschichte der Elementar-Mathematik. III. Proportionen, Gleichungen.* 3rd edition. Pp. 239. RM. 10. 1937. (Walter de Gruyter, Berlin)

L. Turner. *Examples in practical mathematics. Third year (senior) course for technical colleges.* Pp. 112. 2s. 1937. (Arnold)

B. L. van der Waerden. *Moderne Algebra. I.* 2nd edition. Pp. x, 272. Geh. RM. 15.60 ; geb, RM. 17.20. 1937. Grundlehren der mathematischen Wissenschaften, 33. (Springer, Berlin)

P. Wijdenes. *Five place tables. Logarithms of integers, logarithms and natural values of trigonometric functions in the decimal system for each grade from* 0 *to* 100 *grades with interpolation tables.* Pp. 168. Fl. 2.50. 1937. (Noordhoff, Groningen)

Origins of Clerk Maxwell's electric ideas as described in familiar letters to William Thomson. Edited by Sir Joseph Larmor. Pp. 56. 3s. 6d. 1937. (Cambridge)

LONDON BRANCH.

Programme for 1937-1938.

All meetings will be held at Bedford College, Regent's Park, N.W. 1.

1937. Saturday, Oct. 9th, 3.15 p.m.	"The First Year's Course in Geometry."—C. W. Parkes, Esq., M.A., B.Sc. (*Staff Inspector, Board of Education*).
Friday, Nov. 12th, 6.30 p.m.	"Some Points in the Teaching of Mechanics."—W. M. Roberts, Esq., M.A. (*Professor of Mathematics, Royal Military Academy*).
Saturday, Nov. 27th, 3.15 p.m.	Presidential Address: "The Needs and Difficulties of the Average Pupil."—L. C. Hogben, Esq., M.A., D.Sc., F.R.S. (*Regius Professor of Natural History in the University of Aberdeen*).
1938. Saturday, Jan. 29th, 3.15 p.m.	Annual Business Meeting, followed by discussion of members' topics.
Friday, Feb. 18th, 6.30 p.m.	"The Place of Logic in the Teaching of Mathematics."—M. Black, Esq., M.A. (*Institute of Education*).
Saturday, March 19th.	"Music and Mathematics": a discussion between Miss E. J. Ternouth, M.A. (*Lecturer in Mathematics, University of Reading*), and A. H. G. Palmer, Esq., M.A., Mus.Bac., F.R.C.O. (*Headmaster, Great Yarmouth Grammar School*), with musical illustrations.

QUEENSLAND BRANCH

Report for the year 1936-37, presented to the Annual Meeting on 9th April, 1937.

The Annual Meeting was held at the University on 3rd April, 1936: the report for the year then ending and the financial statement were presented and were adopted. The committee for the coming year was elected. Professor Simonds' Presidential Address was on the subject, "Leonardo da Vinci."

During the year three ordinary meetings were held, all at the University. On 3rd June, Mr. J. P. McCarthy, M.A., read a paper on "The early mathematical work of Christian Huygens". At the next meeting, held on 31st July, Mr. E. W. Jones, B.A., read a paper on "Geodesy", and at the third, held on 13th November, Mr. J. C. Deeney, B.A., read a paper entitled "Building a Sky-scraper".

The number of members at present is 27 of whom 11 are members of the Mathematical Association.

The statement of receipts and expenses shows a credit balance of £5 19s. 2d., which is an increase on that of the previous year.

Copies of the *Mathematical Gazette* are received and circulated as usual. The attendance at meetings has been satisfactory and our thanks are due to those who prepare for the various meetings.

J. P. McCarthy, Hon. Sec.

THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

By Edwin W. Schreiber, *Secretary.*

The Eighteenth Annual Meeting of the National Council of Teachers of Mathematics was held in Chicago, February 19-20, 1937. This was the largest meeting in the history of the Organization, 836 registered and the total attendance was well in excess of 1,000. The opening meeting began at 8 p.m. in the Grand Ballroom of the Palmer House with President Martha Hildebrandt in the Chair. The Address of Welcome was made by James E. McDade, Asst. Superintendent of Schools, Chicago, and the Response by Mrs. Florence Brooks Miller, First Vice-President, Shaker Heights, Ohio. Professor Albert A. Bennett, Brown University, spoke on " Mathematics and Life ". Beulah I. Shoesmith of Hyde Park High School, Chicago, presented through some twenty high school students a series of projects on high school mathematics which was much appreciated. The results of the Annual election were as follow: For Second Vice-President, J. T. Johnson, Chicago Normal College; for three members of the Board of Directors, William Betz of Rochester, N.Y., H. C. Christofferson, Oxford, Ohio, and Edith Woolsey, Minneapolis, Minnesota.

Three simultaneous meetings were held at 9.30 a.m., Saturday morning. (1) Arithmetic Section, (2) High School Section, (3) Junior College Section. For the Arithmetic Section there were three papers, " Significance, Meaning and Insight, These Three " by B. R. Buckingham, " Teaching Pupils to Teach Themselves " by H. G. Wheat, and " Methods and Devices for the Development of Resourcefulness " by Arthur S. Otis. There were four papers in the High School Section, " Providing for Individual Needs in Mathematics " by Virgil S. Mallory, " An Experiment Dealing with Slow Learning Pupils in Mathematics " by Raleigh Schorling, " Curriculum Hints from the Night School " by C. O. Donnelly, and " Revealing the Vitality of Mathematics " by Kate Bell. Three papers were presented at the Junior College Section, " Off the Beaten Path " by Mayme I. Logsdon, " Some Problems of Junior College Mathematics " by H. W. Bailey, and " Business and Finance Mathematics in Junior College Curriculum " by W. S. Schlauch. The Discussion Luncheon held at noon on Saturday was a distinct success, 409 attending this function. At the General Meeting held at 2.30 p.m., Mr. William Betz presented a moving picture entitled " Classroom Project in Intuitive Geometry ". Professor W. D. Reeve addressed the audience on " Mathematics and the Integrated Program ". Three moving pictures presented through the courtesy of the University of Chicago were much appreciated by the audience.

The Annual Banquet in the Grand Ballroom of the Palmer House was indeed a fitting close to the two-day session and was attended by 275. Special recognition was given to the Honorary President Dr. Herbert E. Slaught in honour of his 75th birthday. A novel part of the occasion was a speech by Professor Slaught broadcast to the group from a record previously prepared. President Hildebrandt moved the adoption of a set of resolutions honouring Professor H. E. Slaught, which were unanimously adopted by a rising vote. Professor Charles A. Hutchinson read with keen insight the address which had been prepared by Professor H. E. Buchanan of Tulane University, New Orleans, on " A New Deal from Old Cards ". Due to illness Professor Buchanan was unable to appear. The Mathematical Exhibit occupying the entire available space in the foyer leading to the Grand Ballroom was a very attractive feature of the Annual Convention. Miss Laura E. Christman, Seen High School, Chicago, was General Chairman of this function.

JOURNALS RECEIVED.

When no number is attached, no part has been received since a previous acknowledgment.

Abhandlungen aus dem Mathematischen Seminar der Hamburgischen Universität. **12**: 1.

American Journal of Mathematics. **58**: 4; **59**: 1, 2.

American Mathematical Monthly. **43**: 7, 8, 9, 10; **44**: 1, 2, 3, 4, 5.

Anales de la Sociedad Científica Argentina. **121**: 6; **122**: 1, 2, 3, 4, 5, 6; **123**: 1, 2.

Annales de la Société Polonaise de Mathématique.

Annali della R. Scuola di Pisa. Ser. 2. **6**: 1, 2.

Annals of Mathematics. **37**: 3, 4; **38**: 1, 2.

Anuario (Univ. Nac. de la Plata).

Berichte über die Verhandlungen der Akad. der Wiss. zu Leipzig: Math.-Phys. Klasse.

Boletin Matematico. **9**: 5, 6, 7, 8, 9, 10.

Boletín del Seminario Matemático Argentino.

Bollettino della Unione Matematica Italiana. **15**: 4, 5; **16**: 1, 2.

Bulletin of the American Mathematical Society. **42**: 9, 10, 11, 12; **43**: 1, 2, 3, 4, 5, 6.

Bulletin of the Calcutta Mathematical Society. **27**: 3-4; **28**: 1, 2, 3-4.

Bulletin de l'Académie Royale Serbe. A. 3.

Contribución al Estudio de las Ciencias Físicas y Matemáticas. S. Mát. **1**: 1, 2, 3.

Duke Mathematical Journal. **2**: 3, 4; **3**: 1, 2.

L'Enseignement Mathématique. **35**: 1-2, 3-4, 5-6; **36**: 1-2.

Esercitazioni Matematiche. Ser. 2. **9**: 5-6-7, 8-9-10.

Gazeta Matématica. **41**: 12; **42**: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.

Half-Yearly Journal of the Mysore University.

Jahresbericht der Deutschen Mathematiker-Vereinigung. **46**: 5-8, 9-12; **47**: 1-4.

Japanese Journal of Mathematics. **13**: 1, 2.

Journal of the Faculty of Sciencies, Hokkaido. **5**: 1-2, 3-4.

Journal of the Indian Mathematical Society. N.S. **2**: 3, 4, 5, 6.

Journal of the London Mathematical Society. **11**: 4; **12**: 1, 2.

Journal of the Mathematical Association of Japan. **18**: 5, 6; **19**: 1, 2, 3.

Journal de l'Institut Mathématique d'Ukraine. **1**: 3-4: **2**: 1, 2, 3.

Matemática Elemental. **5**: 4-5, 6.

Mathematical Notes. 30.

Mathematics Student. **4**: 1, 2, 3.

Mathematics Teacher. **29**: 6, 7, 8; **30**: 1, 2, 3, 4, 5.

Monatshefte für Mathematik und Physik.

National Mathematics Magazine (Louisiana). **11**: 1, 2, 3, 4, 5, 6, 7, 8.

Nieuw Archief voor Wiskunde.

Periodico di Matematiche. Ser. 4. **16**: 4; **17**: 1, 2.

Proceedings of the Edinburgh Mathematical Society. Ser. 2. **5**: 1, 2.

Proceedings of the Physico-Mathematical Society of Japan. Ser. 3. **18**: 8, 9, 10, 11, 12; **19**: 1, 2, 3, 4, 5, 6.

Publicaciones de la Facultad de Ciencias Físcio-Matemáticas Universidad Nacional de la Plata.

Publications de la Faculté des Sciences de Masaryk. 226, 229, 230, 233, 235, 236.

Recueil Mathématique (Moscow). N.S. 1 : 1, 2, 3, 4, 5, 6 ; 2 : 1.

Rendiconti del Seminario Matematico e Fisico di Milano. 1-9.

Revista de Ciencias (Peru). 417, 418, 419.

Revista Matemática Hispano-Americana (Madrid).

School Science and Mathematics. 36 : 7, 8 ; 37 : 1, 2, 3, 4, 5, 6.

Science Progress. 122, 123, 124, 125.

Scripta Mathematica. 4 : 2, 3.

Sitzungsberichte der Berliner Mathematischen Gesellschaft. 35.

Studia Mathematica. 6.

Universidad (Zaragoza). 13 : 2, 3, 4 ; 14 : 1.

Unterrichtsblätter für Mathematik und Naturwissenschaften. 42 : 8, 9, 10 ; 43 : 1, 2, 3, 4, 5, 6.

Wiskundige Opgaven met de Oplossingen. 16 : 5.

BOOKS RECEIVED FOR REVIEW.

A. Bakst. *Approximate computation.* Pp. xvi, 287. $1.75. 1937. Twelfth Yearbook of the National Council of Teachers of Mathematics. (Bureau of Publications, Teachers College, Columbia University, New York)

E. T. Bell. *Men of mathematics.* Pp. 653. 12s. 6d. 1937. (Gollancz)

E. J. Berg. *Heaviside's operational calculus as applied to engineering and physics.* 2nd edition. Pp. xv, 258. 18s. 1936. Electrical engineering texts. (McGraw-Hill)

H. Cramér. *Random variables and probability distributions.* Pp. viii, 121. 6s. 6d. 1937. Cambridge tracts, 36. (Cambridge)

G. R. Davies and **D. Yoder.** *Business statistics.* Pp. vii, 548. 17s. 6d. 1937. (John Wiley and Sons, New York ; Chapman and Hall)

C. V. Durell. *School Certificate algebra.* Pp. xv, 399, xxxii, xliii. With answers, 5s. 1937. (Bell)

T. H. Fallows. *Examples in practical mathematics for first-year students.* Pp. vii, 71. 1s. 3d. 1937. (Dent)

R. J. Fulford. *Junior revision and mental tests in arithmetic and algebra.* Pp. 108. 1s. 6d. ; without answers, 1s. 1937. (University Tutorial Press)

S. L. Green. *Hydro- and aero-dynamics.* Pp. viii, 166. 12s. 6d. 1937. (Pitman)

H. Kestelman. *Modern theories of integration.* Pp. viii, 252. 17s. 6d. 1937. (Oxford)

A. Landé. *Principles of quantum mechanics.* Pp. xii, 119. 7s. 6d. 1937. (Cambridge)

J. L. Latimer and **T. Smith.** *A course in geometry.* Pp. 388. 4s. 6d. In two parts, 2s. 6d. each. 1937. (Harrap)

W. Lietzmann. *Der pythagoreische Lehrsatz.* 5th edition. Pp. iv, 43. RM. 0·90. 1937. Mathematisch-physikalische Bibliothek, Reihe I, 3. (Teubner)

W. Lietzmann. *Von der pythagoreischen Gleichung zum Fermatschen Problem.* 5th edition. Pp. 48. RM. 0.90. 1937. Mathematisch-physikalische Bibliothek, Reihe I, 91. (Teubner)

J. V. McKelvey. *Calculus.* Pp. ix, 420. 12s. 6d. 1937. (Macmillan)

W. F. Osgood. *Mechanics.* Pp. xv, 495. 21s. 1937. (Macmillan)

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There is evidence that members of the Association are insufficiently aware of the resources of their Library and do not know how to take advantage of them. A descriptive leaflet is being distributed with the present number of the Gazette.

The Librarian reports gifts as follows :

From Mr. **F. C. Boon,** a school algebra and the new edition of his booklet
Puzzle papers in arithmetic - - - - - - 1937

From Mr. **T. A. A. Broadbent:**

I. NEWTON — Mathematische Principien der Naturlehre {1 (1872) rep.} [1933]
Photostatic reproduction of the translation by J. P. Wolfers.

From Prof. **G. R. Goldsbrough:**

Origins of Clerk Maxwell's Electric Ideas - - 1937
" As described in familiar letters to William Thomson."

From Mr. **P. Hall:**

A. SPEISER — Theorie der Gruppen von endlicher Ordnung {3} Grundlehren 5 1937

H. ZASSENHAUS — Gruppentheorie; I Hamburger Einzelschriften 21 1937

From Dr. **H. P. Hudson,** continuations of the London *Proceedings* and the Palermo *Rendiconti.*

From Rev. **J. J. Milne,** a few schoolbooks, together with

APOLLONIUS — De Sectione Rationis Libri duo - - - - - 1706
Halley's translation from Arabic into Latin, with his restoration of Apollonius' *De Sectione Spatii.*
This is a beautifully executed manuscript copy of the rare original.

M. CHASLES — Porismes d'Euclide - - - - - - - - 1860

T. LEMOYNE — Les Lieux Géométriques - - - - - - - 1923

A. MACFARLANE — Physical Arithmetic - - - - - - - - 1885

C. MACLAURIN — Algebra {3} - - - - - - - - - 1771

G. B. MATHEWS — Projective Geometry - - - - - - - 1914

I. NEWTON — Principia {N. W. Chittenden} - - - - - - 1846
The first American edition of Motte's translation.

PAPPUS — Collectio (3 vols.) - - - - - - 1876, 1877, 1878
The definitive edition by E. Hultsch, which set an insurpassable standard for modern editions of classical works.

A. ROBERTSON — Conic Sections - - - - - - - - - 1802
Elements of Conic Sections - - - - - - - 1818

E. J. ROUTH — Analytical Statics (2 vols.) {2, 3} - - - 1909, 1908

H. SCHMIDT — Tate's Modern Cambist {18} - - - - - - 1881

R. SIMSON — Opera Quaedam Reliqua - - - - - - - 1776
Euclid's *Elements* and *Data* {25 : S. Maynard} - - 1841
Sectionum Conicarum Libri quinque {2} - - 1750
Conic Sections { } - - - - - - - - 1817
An anonymous translation of the first three books of the Latin treatise.

From Miss **K. Reeve,** a number of textbooks, including

W. H. Besant and A. S. Ramsey
Hydromechanics ; I : Hydrostatics (6) - - - 1904

R. A. Herman — Geometrical Optics - - - - - - - 1900

From Mr. **B. Stevens,** the new edition of his philosophy of relativity
The Identity Theory (2) - - - - - 1936

From Prof. **G. N. Watson:**

G. A. Bliss	Algebraic Functions - -	American Colloquium 16	1933
G. Giraud	Fonctions Automorphes - -	Collection Borel	1920
S. Lefschetz	Analysis Situs et Géométrie Algébrique	Collection Borel	1924
N. E. Nörlund	Séries d'Interpolation - - -	Collection Borel	1926

From Mr. **H. J. Woodall,** a copy of *Sphinx* for February 1937 containing his article
On hyper-exponential numbers

From the Mathematical Association of America :

D. E. Smith and J. Ginsburg
Mathematics in America before 1900 - Carus 5 1934

The following has been bought :

J. Tropfke — Geschichte der Elementar-Mathematik (2 vols.) 1902, 1903
In subsequent editions this work reaches encyclopaedic dimensions.

INDEX TO VOLUME XXI.

The index to Volume XXI will be circulated with the *Gazette* for February 1938.

LIVERPOOL BRANCH.

Meetings arranged for the session are :

1937.

6th Dec. "Mathematics in the Junior School."—C. E. Robinson, Esq., Headmaster, Victoria Road School, Runcorn.

1938.

17th Jan. "The Organization of Schools, with special reference to the Teaching of Mathematics."—C. F. Mott, Esq., M.A., Director of Education of City of Liverpool.

28th Feb. "Ideas of Elementary Mathematical Analysis for Senior Students in Secondary Schools."—Dr. F. W. Bradley, M.Sc., Liverpool University.

2nd May. "The Value of the History of Mathematics as an aid to Teaching."—Professor W. P. Milne, M.A., D.Sc., Leeds University.

Meetings are held in the University of Liverpool at 5.30 p.m.

Secretary : T. H. Jackson, B.A., M.Ed., Wyngarth, Allerton Drive, Liverpool, 18.

NORTH WALES BRANCH.

MEETINGS: OCTOBER 1936—JUNE 1937.

1936.

28th Oct. General discussion on the mathematical papers set for the School Certificate and Higher Certificate Examinations of the Central Welsh Board in July 1936. The following motions were passed:

"That this meeting approves of the present trend of School Certificate Mathematics papers, but would welcome still further separation of the easy type question from the harder questions."

"That this meeting suggests that the Geometry syllabus should be revised and brought up to date, instead of the present Euclidean references."

1937.

3rd Mar. Mr. H. Wilson of Swansea University gave a lecture on "Post-Certificate Geometry". He outlined a course based on Volume I of Baker's *Foundations of Geometry*, and stressed the necessity for parallel courses of metrical geometry and theoretical geometry. The general opinion of the meeting was that such a course was not suitable for inclusion in the syllabus covered by Higher Certificate pupils.

26th May. Dr. H. Greenwood gave an extremely interesting lecture on "Some aspects of Greek Mathematics and its contrast to modern Mathematics". The lecture concluded with the application of Greek Mathematics to Diophantine Algebra and Pythagorean Arithmetic.

16th June. Mr. E. G. Phillips of Bangor University gave a very interesting paper on "Methods of marking matriculation mathematics papers". He first outlined the general principles involved, and then explained in detail the usual methods of marking specific questions taken from recent examination papers.

S. MOSES.

UNIVERSITY OF LONDON.

A COURSE of three lectures on "The Artificial Transmutation of Matter" will be given at King's College, Strand, London, W.C. 2, by Professor James Chadwick, F.R.S., Lyon Jones Professor of Physics in the University of Liverpool, at 5.30 p.m. on 2nd, 7th and 8th December, 1937.

Syllabus: Lecture I. Historical and General Survey.

Lectures II and III. The Experimental Results and their Interpretation.

Admission free. without ticket.

BOOKS RECEIVED FOR REVIEW

E. T. Bell. *The handmaiden of the sciences.* Pp. viii, 216. 9s. 1937. (Baillière, Tindall & Cox)

W. H. E. Bentley and **E. W. M. Potts.** *Geometry. II. Transition to deductive reasoning.* Pp. 175. 2s. 6d. 1937. (Ginn)

O. K. Buros. *Educational, psychological and personality tests of* 1936. Pp. 141. 75 cents. 1937. (School of Education, Rutgers University, New Brunswick, New Jersey)

R. Carnap. *Logical Syntax of Language.* Pp. xvi, 352. 25s. 1937. (Kegan Paul)

G. R. Clements and **L. T. Wilson.** *Manual of mathematics and mechanics.* Pp. vii, 266. 15s. 1937. (McGraw-Hill)

H. R. Cooley, D. Gans, M. Kline and **H. E. Wahlert.** *Introduction to mathematics.* Pp. xviii, 634. 10s. 6d. 1937. (Harrap)

H. Dingle. *Through science to philosophy.* Pp. vii, 363. 15s. 1937. (Oxford)

C. V. Durell and **A. Robson.** *Advanced algebra. II, III.* Pp. xi, 195-510, xxiii-xlvi, 5. 12s. 6d. Part II, 6s. Part III, 7s. 6d. 1937. (Bell)

E. Hopf. *Ergodentheorie.* Pp. v, 83. RM. 9.80. 1937. Ergebnisse der Mathematik, Band V, Heft 2. (Springer)

T. M. MacRobert and **W. Arthur.** *Trigonometry. II. Higher trigonometry.* Pp. xiii, 205-341. 4s. 6d. 1937. (Methuen)

S. Mitra and **G. K. Dutt.** *A text book of the differential calculus.* Pp. xiv, 302. 10s. 1937. (Heffer, Cambridge)

G. Le Myre. *Le Baccara.* Pp. 204. 12 fr. 1935. (Hermann)

C. W. O'Hara and **D. R. Ward.** *An introduction to projective geometry.* Pp. ix, 298. 12s. 6d. 1937. (Oxford)

B. C. Patterson. *Projective geometry.* Pp. xiii, 276. 17s. 6d. 1937. (John Wiley and Sons, New York ; Chapman and Hall)

F. B. Pidduck. *Lectures on the mathematical theory of electricity.* Pp. viii, 110. 7s. 6d. 1937. (Oxford)

H. L. Rietz, J. F. Reilly and **R. Woods.** *Plane and spherical trigonometry.* Pp. xi, 168, 72, xiii. 10s. 1936. (Macmillan)

R. Rothe. *Höhere Mathematik für Mathematiker, Physiker und Ingenieure.* Teil IV, Hefte 4, 5, 6. Pp. 51-106, 54, 55-105. RM. 1.80 each. 1937. Teubners mathematische Leitfaden, 36, 37, 38. (Teubner)

S. Saks. *Theory of the integral.* 2nd revised edition ; English translation by L. C. Young. Pp. vii, 347. $5. 1937. Monografie Matematyczne, 7. (Warsaw)

H. A. Simmons and **G. D. Gore.** *Plane trigonometry with five-place tables.* Pp. viii, 201, 81. 10s. 1937. (John Wiley and Sons, New York ; Chapman and Hall)

E. C. Titchmarsh. *Introduction to the theory of Fourier integrals.* Pp. x, 390. 17s. 6d. 1937. (Oxford)

C. Warrell. *Sane arithmetic for seniors. I.* Pp. 64. Paper 10d. ; limp cloth 1s. 3d. 1937. (Harrap)

H. Webb and **J. C. Hill.** *Arithmetic of daily life. I.* Pp. 96. 1s. 3d. 1937. (Cambridge)

H. G. Wheat. *The psychology and teaching of arithmetic.* Pp. x, 591. 8s. 6d. 1937. (D. C. Heath, Boston ; Harrap)

E. T. Whittaker. *A treatise on the analytical dynamics of particles and rigid bodies with an introduction to the problem of three bodies.* Fourth edition. Pp. xiv, 456. 25s. 1937. (Cambridge)

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(3) WHITTAKER, EDMUND TAYLOR, M.A., Hon. Sc.D., Hon. LL.D., F.R.S., Professor of Mathematics in the University of Edinburgh; formerly Fellow of Trinity College, Cambridge; Honorary Fellow of the Faculty of Actuaries, and Honorary Foreign Member of the R. Accademia dei Lincei (Rome); 48, George Square, Edinburgh. (President, 1919-1920.)

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(1) Joined the Association in 1905.

(2) Joined the Association in 1885.

(3) Joined the Association in 1898.

SUBSCRIBING MEMBERS

The date indicates the year in which the member joined the Association.

1935 ABLEY, LEONARD ALFRED VALENTINE, B.Sc., Latymer School, Edmonton; 24, Constance Road, Whitton, Twickenham, Middlesex.

1908 ADAMS, CHARLES WILFRID, M.A., Haileybury College, Hertford.

1927 ADAMS, LESLIE JAMES, B.Sc. (Eng.), Doncaster Technical College; 9, Grove Vale, Wheatley Hills, Doncaster, Yorks.

1914 ADAMS, Miss LOUISE DORIS, B.Sc., H.M. Inspector of Schools; Brookside, Garstang Road, Fulwood, Preston, Lancs.

1931 ADAMS, Miss MAY LOUISE, B.Sc., Great Yarmouth High School for Girls; 55, Apsley Road, Great Yarmouth, Norfolk.

1924 ADAMS, Right Rev. WALTER ROBERT, M.A., D.D., Bishop of Kootenay, British Columbia; formerly Fellow of Durham University; Bishopsgarth, Vernon, British Columbia, Canada.

1923 ADE, FRANK CHARLES, M.A., Eltham College; Jordans, 81, Court Road, Eltham, London, S.E.9.

1903 ADLARD, MARTYN, M.A., Barnard Castle School, Barnard Castle, Co. Durham.

1935 AKHURST, Miss EVELYN GLADYS, B.Sc., County School for Girls, Godstone Road, Purley, Surrey.

1933 ALEXANDER, CONEL HUGH O'DONEL, B.A., Winchester College; 68, Kingsgate Street, Winchester, Hants.

1923 ALLEN, Miss DOROTHY BELL, B.A., St. Swithun's School for Girls, Winchester; The Old Malthouse, Upper Clatford, Andover, Hants.

1936 ALLEN, MISS HAZEL VINCENT, M.Sc., Regent Street Polytechnic, London, W.1; 4, Woodville Road, Ealing, London, W.5.

1927 ALLEN, JOHN MAURICE, M.A., B.Sc., Head of Math. and Physics Department, Melbourne Technical College; 41, Nirvana Avenue, East Malvern, S.E.5, Melbourne, Victoria, Australia.

1937 ALLENDER, ALAN GORDON, B.Sc., Yardley Secondary School, Birmingham; 20, Dean Road, Erdington, Birmingham

1930 ALLETSON, D'ARCY COVENTRY, B.A., Restabrig, Milner Road, Rondebosch, Cape Town, South Africa.

1935 ALLITT, TOM RODNEY, B.Sc., Royal Latin School, Buckingham; 23, Stratford Road, Buckingham.

1934 ALLMAN, GEORGE, M.A., Grammar School, Dudley; Westmead, Himley Road, Dudley, Worcs.

1929 ANDERSEN, PERCIVAL NEVILL WEBSTER, B.A., B.Sc., Boys' High School, North Sydney; Falcon Street, Crow's Nest, New South Wales, Australia.

1932 ANDERSON, Miss ALICE MARY, B.A., Whalley Range High School for Girls, Manchester, 16.

1921 ANDERSON, JAMES, M.A., The Grammar School, Doncaster; 274, Thorne Road, Doncaster, Yorks.

1925 ANDRESS, Miss FLORENCE MAUD, B.A., Coborn School for Girls; 29-33, Bow Road, London, E.3.

1923 ANDREWS, SYDNEY THOMAS GILES, B.Sc. (Eng.), M.I.Ae.E., Raine's Secondary School, London, E.; Maybank, 9, Acacia Drive, Thorpe Bay, Essex.

1920 ANSTEY, JOSEPH GORDON, B.Sc., Bacup and Rawtenstall Grammar School; 171, Bacup Road, Cloughfold, Rossendale, Lancs.

1935 APPLEBY, Miss ENID, B.Sc., Woodford County High School; 44, Montalt Road, Woodford Green, Essex.

1935 APPLEBY, ROBERT EDWARD, M.Sc., Johnston School, Durham; Dougwin House, Durham Moor Crescent, Durham.

1935 ARCHER, ALFRED GEOFFREY, M.A., Stowe School, Buckingham.

1910 ARCHIBALD, Miss JANE DORA, B.A., M.A., H.M. Inspector of Schools; 84B, Banbury Road, Oxford.

1910 ARCHIBALD, RAYMOND CLARE, A.B., A.M., Ph.D., Hon. LL.D., Hon. D.Univ.Padua, Professor of Mathematics, Brown University, Providence, Rhode Island, U.S.A.

1933 ARKELL, DANIEL JOHN, B.Sc., St. Edward's College, Cottonera, Malta.

1933 ARMISTEAD, WILLIAM, M.A., Main A, Christ's Hospital, Horsham, Sussex.

1935 ARMITAGE, FRANCIS WILLIAM, M.A., Sidcot School, Winscombe, Somerset.

1927 ARNDT, JOHANNES GUSTAV AUGUST, B.A., M.Sc., D.Phil., University College of the Orange Free State, Bloemfontein; 27, King Edward Road, Bloemfontein, South Africa.

1936 ASHBURNER, ALFRED EDWARD, B.Sc., Hutton Grammar School; Menden, Tolsey Drive, Hutton, Nr. Preston, Lancs.

1937 ASHBY, Miss WINIFRED AMELIA, B.A., Leicester Collegiate School for Girls; 130, Stamford Road, Handsworth, Birmingham, 20.

1927 ASHLEY, GEORGE ERNEST, B.Sc., Sheerness Technical Institute; 301, Minster Road, Sheerness, Kent.

1933 ASHWIN, GERARD, W. F., B.A., Adam's Grammar School, Wem, Shropshire.

1935 ASLIN, Miss ETHEL LOUISE, B.A., Eastbourne High School; Hadcombe, Baldwin Avenue, Eastbourne, Sussex.

1930 ASTON, SIDNEY THOMAS, B.Sc., St. Bees School; Eaglesfield House, St. Bees, Cumberland.

1922 ATACK, Miss MARY, B.Sc., The High School for Girls, West Hartlepool, Co. Durham.

1935 ATHERTON, REGINALD ROBERT, M.A., Oldershaw School for Boys, Wallasey; 9, Stanley Avenue, Wallasey, Cheshire.

1913 ATKIN, ARNOLD LONSDALE, M.A., District Inspector of Schools, L.C.C.; 25, Nassau Road, Barnes, London, S.W.13.

1930 ATKINS, EDGAR RAYMOND, B.Sc., Technical College, Swansea; Eryl, Queen's Road, Sketty, Swansea, Glam.

1930 ATKINSON, CHARLES, B.Sc., Reigate Grammar School; 41, Broadhurst Gardens, Reigate, Surrey.

1923 ATKINSON, EDWIN JOHN, M.Sc., Head Master, Municipal Secondary School for Boys, Newport, Mon.; 15, Fields Road, Newport, Mon.

1926 ATKINSON, Miss ENID DORA CAULFIELD, B.A., Fulham County Secondary School; 7B, Carlton Road, Putney, London, S.W.15.

1911 ATKINSON, ERNEST CUTHBERT, M.A., F.R.A.S., West View, 10, Eastbury Avenue, Northwood, Middlesex.

1924 ATTFIELD, Miss ESTHER MILDRED, M.A., Head Mistress of Howard Gardens High School; 13A, Piercefield Place, Cardiff, Glam.

1927 AVERY, ARCHIBALD JOHN LESLIE, M.A., Technical College, Derby; 11, Avondale Road, Derby.

1936 AYRES, FRANK, M.Sc., Goldsmiths' College, London; 36, Craven Avenue, Ealing, London, W.5.

1936 AYYANGAR, A. A. KRISHNASWAMI, M.A., L.T., Maharajah's College, Mysore, South India; 321, D. Subbiah Road, Mysore, South India.

1936 BAGGOTT, GEORGE STANLEY, B.Sc., 4, Park Drive, Ilkeston, Derbyshire.

1936 BAHADUR, KANWAR, B.A., M.A.; Sanatana Dharma College, Nawab-Ganj, Cawnpore, India.

1910 BAKE, HENRY JOHN TYACK, M.A., M.Sc., Pine Trees, Harlow Moor Road, Harrogate, Yorks.

1926 BAKER, LAURENCE HENRY GEORGE, B.A., The Grammar School, Hastings; 11, Elphinstone Road, Hastings, Sussex.

1926 BAKER, NORMAN BUTLER, M.C., B.Sc., Wanstead High School, Essex; 157, Hermon Hill, South Woodford, London, E.18.

1912 BALDWIN, EVAN, M.Sc., Waterloo-with-Seaforth Grammar School; 21, Woodville Avenue, Great Crosby, Liverpool.

1919 †BALDWIN, OSWALD RUSHTON, M.A., B.Sc., Ph.D., Head Master of St. George Secondary School, Bristol, 5; 40, Salisbury Road, Redland, Bristol, 6.

1912 BALDWIN, ROBERT, M.A., M.Sc., Wallasey Grammar School; 10, Oarside Drive, Wallasey, Cheshire.

1924 BALEKAR, SADASHIV BALAJI, M.A., Robertson College, Jubbulpore, Central Provinces, India.

1933 BALL, Miss EDNA FLORENCE, B.Sc., A.K.C., Rosebery County School for Girls, Epsom; Highcliffe, Friends Road, Purley, Surrey.

1937 BARBER, ARTHUR, L.C.P., Moorside Senior School, Swinton; Sunnyside, 69, Station Road, Pendlebury, Lancs.

1937 BARCLAY, WILLIAM, M.A., B.Sc., Acton Technical College, High Street, Acton, London, W.3.

1936 BARFIELD, LESLIE H., B.Sc., The Grammar School, Gillingham, Dorset; 2, Oxford Cottages, Victoria Road, Gillingham, Dorset.

1928 BARNARD, Miss EDITH LUCY (Math. Trip.), Godolphin and Latymer School, Hammersmith; 26, Blomfield Road, London, W.9.

1937 BARNARD, GRAHAM SWAFFER, B.Sc., Frome County School; 31, Fromefield, Frome, Somerset.

1902 BARNARD, SAMUEL, M.A., Late Fellow and Lecturer of Emmanuel College, Cambridge; Leahurst, Towyn, Merioneth, South Wales.

1934 BARNES, Miss ELEANOR, B.Sc., Selhurst Grammar School for Girls, The Crescent, Croydon, Surrey.

1935 BARNES, WILLIAM CHARLES, B.Sc., Sexey's School, Bruton, Somerset.

1922 BARNETT, Miss PRISCILLA MARTHA, B.Sc., Cambridge and County High School for Girls; 28 Orchard Street, Cambridge.

1929 BARNETT, WALTER GEORGE, A.M.I.C.E., The Old Rectory, Edingthorpe, North Walsham, Norfolk.

1902 BARR, CHARLES JOHN HENRY, M.A., Head Master of the Leas Preparatory School for Boys, Hoylake, Cheshire; 40, Eversfield Place, St. Leonards-on-Sea, Sussex.

1929 BARRON, GEORGE, B.Sc., Morley Grammar School; Thornfield Terrace, Rein Road, Morley, Leeds, Yorks.

1936 BARTON, ALAN, B.A., Blundell's School, Tiverton, Devon.

1935 BARTON, ERIC, B.A., Charterhouse, Godalming, Surrey.

1935 BARTRAM, CECIL WILLIAM, M.Sc., Woolwich Polytechnic, S.E.18; 18, Richmond Road, Wanstead, London, E.11.

1922 BARTRAM, Miss HELEN, M.A., formerly Head Mistress of the King's Warren School, S.E.18; 36, Arden Road, London, N.3.

1933 BARWELL, CHARLES ROBERT, M.Sc., Netherthorpe Grammar School, Staveley, Chesterfield, Derbyshire.

1897 †BATES, GEORGE NEWTON, M.A., Rockley, St. Mildred's Avenue, Ramsgate, Kent.

1922 BATLEY, Miss EDITH MARGARET, B.Sc., Bedford High School; 6 St. Michael's Road, Bedford.

1924 BATSON, Miss JESSIE MARY, B.A., Northampton School for Girls; 31 Beech Avenue, Northampton.

1935 BATTEN, THOMAS CHARLES, M.A., B.Sc., The County School, Sutton, Surrey; Whistlewynd, 5 Upper Mulgrave Road, Cheam, Surrey.

1936 BATTERBEE, HERBERT HART, M.A., Blundell's School, Tiverton, Devon; Old House, Blundell's School, Tiverton, Devon.

1923 BAXTER, ERIC FRANK, M.A., M.Sc., The University, Durham; 6 Fieldhouse Terrace, Durham.

1918 BAXTER, HENRY ARNOLD, M.A., Liverpool Institute, Mount Street, Liverpool.

1931 BAYLIS, Miss BERTHA MARY, B.A., Girls' High School, Lincoln; 4 Minster Yard, Lincoln.

1937 BEACH, GEORGE LEWIN, B.A., Blandford Grammar School; Waterford House, Blandford, Dorset.

1927 BEAMES, FREDERICK, B.Sc., 7 Mansfield Road, Reading, Berks.

1933 BEANEY, KENNETH JACK, B.Sc., Battersea Grammar School; 145 Amesbury Avenue, Streatham Hill, London, S.W.2.

1931 BEARD, ROBERT ERIC, A.I.A., 32 Dawlish Drive, Leigh-on-Sea, Essex.

1898 †BEARD, WALTER FRANCIS, M.A., M.Sc., Horton Cottage, The Layne, Rolvenden, Cranbrook, Kent.

1924 BEARDSMORE, TOM ARCHIBALD, O.B.E., M.Sc., Head Master of Alleyne's Grammar School, Stone, Staffs.

1932 BEARDWOOD, HERBERT, M.Sc., Rothwell Grammar School; 219, Leeds Road, Newton Hill, Nr. Wakefield, Yorks.

1906 BEAVEN, CECIL LIVINGSTONE, M.A., Assistant Professor in the Royal Military Academy, Woolwich; The Lodge, Oakwood Close, Chislehurst, Kent.

1906 BEAVEN, HAROLD CASTLEREAGH, M.A., Clifton College, Bristol; 60 Clifton Park Road, Clifton, Bristol.

1932 BEAVEN, JOHN ALFRED DISRAELI, M.A., The Grammar School, Wakefield, Yorks.

1928 BECK, HERBERT OSMOND, M.A., King Edward VI School, Stafford; The Crescent, Walton-on-the-Hill, Staffs.

1936 BEDDOW, ARTHUR JOSIAH COMYNS, B.A., Mill Mead, Shrewsbury; 95, Clifton Road, Rugby.

1921 BEECHING, Miss AMY VIOLET, B.Sc., Southlands, South Hill Avenue, Harrow, Middlesex.

1919 BEENY, FRANCIS WINTON, St. Michael's School, Eastcote, Pinner, Middlesex

1936 BEGGS, Miss MARGARET A., B.A., Commonweal Lodge School, Purley; 59 Ross Road, Wallington, Surrey.

1936 BELL, Miss CHRISTINA S., M.A., Wellington East Girls' College, Wellington, New Zealand.

1936 BELL, JAMES, B.Sc., County School, Hawarden, Flintshire; The Nook, Penyfford, Chester.

1937 BENNELL, Miss MARGERY MARY, B.Sc., Erdington Secondary School, Birmingham; 7 Thornton Road, Clapham Park, London, S.W.12.

1910 BENNETT, Miss AGNES ELIZABETH, M.A., North London Collegiate School for Girls; 40 Lewisham Road, London, N.W.5.

1937 BENNETT, ROGER, B.A., 35, Willows Crescent, Cannon Hill, Birmingham, 12.

1937 BENNETT, Miss WINIFRED ELLISON, B.Sc., The County School, Oxted, Surrey; East Hill Dairy, Oxted, Surrey.

1914 BENTLEY, WILLIAM HENRY ELDRED, B.Sc., Kilburn Grammar School; Rosamona, 4 Meadow Way, Wembley, Middlesex.

1937 BERRY, EDWIN HAROLD, B.Sc., Intermediate School, Romford, Essex; 35 Rosedale Road, Romford, Essex.

1927 BERRY, HAROLD, M.A., Kingswood School; 12 Cavendish Place, Bath, Somerset.

1919 †BERWICK, WILLIAM EDWARD HODGSON, Sc.D., Formerly Fellow of Clare College, Cambridge; Professor of Mathematics in the University College of North Wales, Bangor; Ceinwen Villa, Upper Bangor, North Wales.

1930 BETTS, EDGAR HENRY, B.Sc., John Harvard L.C.C. Senior Boys' School, Gravel Lane, S.E.1; Twynax, Cranes Park Crescent, Surbiton, Surrey.

1915 BICKLEY, WILLIAM GEE, D.Sc., Imperial College of Science and Technology, South Kensington, London, S.W.7; 27, Cuckoo Hill, Pinner, Middlesex.

1917 †BIDEN, Miss MARGARET ELLEN, B.A., Clifton High School for Girls, Bristol; 15 Beaconsfield Road, Clifton, Bristol.

1921 BINDEN, Miss ROSE, B.Sc., County School for Girls, Folkestone; 4 Limes Road, Folkestone, Kent.

1924 BIRBECK, HAROLD LESLIE, M.A., Enfield Grammar School; 6 Grange Drive, Winchmore Hill, London, N.21.

1933 BIRKS, Miss EUNICE WINIFRED, B.Sc., Perse Girls' School, Cambridge; 4 Netherfield House, Queen Edith's Way, Cambridge.

1936 BLACK, JAMES ALEXANDER EDMOND, B.A., Oundle School; Crosby House, Oundle, Peterborough, Northants.

1935 BLACK, MAX, B.A., University of London, Institute of Education, Southampton Row, W.C.1; 81, Belmont Avenue, Cockfosters, Barnet, Herts.

1919 †BLACKBURN-BROWN, Miss ELSIE MARGARET, B.Sc., The Park School, Preston, Lancs.; 76 Victoria Road, Fulwood, Preston, Lancs.

1925 BLACKER, Miss WINIFRED ELSIE BLANCHE, M.A., Croix de Guerre, Wycombe High School; 17 Hardenwaye, Totteridge, High Wycombe, Bucks.

1920 BLACKLOCK, JOHN HENDERSON, M.A., The Grammar School, Rotherham; Rudston, Gerard Road, Rotherham Yorks.

1935 BLACKWELL, ALFRED, M.Sc., Ecclesfield Grammar School, Nr. Sheffield; Milford, Park Terrace, Chapeltown, Sheffield.

1931 BLAMEY, FRANCIS EDWIN, B.Sc., Culford School, Bury St. Edmunds; 30, Melrose Gardens, Hammersmith, London, W.6.

1930 BLAMEY, JOHN ELLERINGTON, B.A., Glendale County School, Wood Green, N.22; 43 Norfolk Avenue, Palmers Green, London, N.13.

1930 BLANKLEY, Miss HANNAH, B.Sc., The Brunts School, Mansfield, Notts.

1931 BLOW, CECIL, M.Sc., Windsor County Boys' School; Wild Rose Cottage, Winkfield, Windsor, Berks.

1922 BOECKER, Miss FLORENCE ADELE, B.A., 167 Adelaide Road, Hampstead, London, N.W.3.

1929 BOLL, WILLIAM HENRY, M.Sc., The Royal Grammar School, Newcastle-upon-Tyne.

1935 BOLLAND, ARTHUR KEMP, B.A., Liverpool College; Besford Grange, Mossley Hill, Liverpool, 18.

1932 BOLTON, Miss GLADYS, B.Sc., Boston High School; 7 South End, Boston, Lincs.

1915 BOND, JOHN STUART, M.A., Cheltenham College, Cheltenham, Glos.

1932 BONSER, GEORGE HENRY, B.A., Plymouth College, Plymouth, Devon.

1910 BOON, FREDERICK CHARLES, B.A., Woodville, Glenwood Road, West Moors, Dorset.

1930 BOORN, Miss DOROTHY EVELYN, B.A., Bournemouth Girls' School; 29 Albemarle Road, Bournemouth, Hants.

1932 BOOTH, NORMAN, B.Sc., Secondary School, Ashton-under-Lyne, Lancs; Ashdene, Matley, Nr. Stalybridge, Cheshire.

1902 †BORCHARDT, WALTER GUSTAV, M.A., B.Sc., formerly of Cheltenham College; The Hall, Montpelier Parade, Cheltenham, Glos.

1924 BORDER, Captain GEORGE WARD, M.A., Boston Grammar School; Ferndale, 18 Hamilton Road, Lincoln.

1935 BORTHWICK, RICHARD, M.A., B.Sc., Leith Academy; 12 Claremont Gardens, Leith, Scotland.

1936 BOSSOM, LESLIE, B.Sc., The Grammar School, Teignmouth, Devon.

1935 BOSWELL, JOSEPH, B.A., B.Sc., Wigan Grammar School; 6 Rivington Avenue, Adlington, Nr. Chorley, Lancs.

1937 BOUSFIELD, DONALD GREENHILL, B.A., Eton College; 2, Weston's Yard, Eton College, Windsor, Bucks.

1932 BOUTON, VINCENT JOSEPH, B.Sc., 9 Christchurch Avenue, Teddington, Middlesex.

1936 BOVET, ARNOLD, B.A., Athlone High School, Johannesburg, South Africa; 32 Cowie Road, Forest Town, Johannesburg.

1937 BOWLEY, EDWARD GEORGE, B.Sc., Darlington Grammar School; 13 Oakdene Avenue, Darlington.

1934 BOWMAN, FRANK, M.A., M.Sc., Head of Mathematics Department, College of Technology, Manchester; 12 Clifton Avenue, Fallowfield, Manchester.

1932 BOWMAN, JAMES ERIC, M.A., Eastbourne College, Eastbourne, Sussex.

1925 BOWMAN, Miss MARGARET EMILY, M.A., Maria Grey College; 4 Holly Lodge Mansions, Highgate, London, N.6.

1923 BOYLE, GEORGE LESLIE, M.A., F.R.G.S., Cambridge and County High School for Boys; 73 Cavendish Avenue, Cambridge.

1936 BOYLING, DENIS HUDSON, 38 Red Down Road, Coulsdon, Surrey.

1936 BOYTER, Miss MARGARET PARKER, B.Sc., George Dixon Secondary School for Girls, Birmingham; 26, Court Oak Road, Harbone, Birmingham, 17.

1929 BOZMAN, Miss AGNES MARY, M.A., Head Mistress, Dame Alice Owen's Girls' School, Islington; 9 Handel Mansions, Handel Street, London, W.C.1.

1937 BRADBURY, Miss DOROTHY, B.Sc., Upper Chine, Shanklin, Isle of Wight; Elmsleigh, Bark Road, Matlock, Derbyshire.

1934 BRADSHAW, WILLIAM NORMAN, B.Sc., County Secondary School, West Bridgford; 107 Selby Road, West Bridgford, Notts.

1932 BRAITHWAITE, GEORGE, M.A., Perse School for Boys; 4, Flamsteed Road, Cambridge.

1935 BRANSDEN, BERNARD, W.D., B.Sc., County Boys' School, Windsor, Berks; Deolali, Hart Road, Thundersley, Essex.

1924 BRETHERTON, JAMES BERESFORD, 105 Bewsey Road, Warrington, Lancs.

1931 BRETT, Miss DORIS, B.A., Uplands School, St. Leonards-on-Sea, Sussex.

1911 †BREWSTER, GEORGE WILLIAM, M.A., Oundle School, Oundle, Northants.

1924 BRIDGEMAN, JOHN WILFRED, B.Sc., A.K.C., Municipal Secondary School, Wolverhampton; 67 Outwoods Drive, Loughborough, Leics.

1910 BRIDGER, Miss ELLEN AGNES, B.Sc., County Girls' School, Maidenhead; 21 Marlow Road, Maidenhead, Berks.

1932 BRIDGER, HAROLD, B.Sc., Bablake School, Coventry, Warwickshire.

1932 BRIEF, MORRIS, B.A., Downham Market Secondary School; c/o Mrs. Haynes, Lynn Road, Downham Market, Norfolk.

1925 BRIGGS, Mrs. VERONICA MARY, B.A., 40 Green Lane, Hendon, London, N.W.4.

1884 †BRILL, JOHN, M.A., late Fellow of St. John's College, Cambridge; Connaught Club, 75 Seymour Street, Marble Arch, London, W.2.

1937 BRIND, Miss EILEEN MARY, B.Sc., Parkfields Cedars Secondary School, Derby; Southfield, Duffield Road, Derby.

1925 BROADBENT, THOMAS ARTHUR ALAN, M.A., Assistant Professor of Mathematics, Royal Naval College, Greenwich; 62, Coleraine Road, Blackheath, London, S.E.3. (Editor, 1931— .)

1937 BRODERICK, TIMOTHY STANISLAUS, M.A., 33 Trinity College, Dublin.

1909 BRODETSKY, SELIG, M.A., B.Sc., Ph.D., F.R.A.S., A.F.R.Ae.S., Professor of Applied Mathematics in the University of Leeds; 3 Grosvenor Road, Headingley, Leeds, 6, Yorks.

1898 BROKE, P. V., M.A., formerly of Eton College; Gladwyns, Hatfield Heath, Bishop's Stortford, Herts.

1934 BROMBY, Miss HELEN, B.Sc., Southampton Grammar School for Girls; 269 Cottingham Road, Hull, E. Yorks.

1937 BROOK, Miss STELLA, B.A., Maidstone Grammar School for Girls; Southcote, Sittingbourne Road, Maidstone, Kent.

1935 BROOKE, Miss EILEEN MINNIE, M.Sc., Grove Park Girls' School, Wrexham; 13 Wat's Dyke Way, Wrexham, Denbighshire.

1937 BROOKES, BERTRAM CLAUDE, M.A., Ottershaw College, Chertsey, Surrey; Meath Cottage, Ottershaw, Chertsey, Surrey.

1919 BROOKES, Miss MABEL LILIAN, B.A., Charles Brooke School for Girls, Camberwell; 18 Lansdowne Road, Bromley, Kent.

1937 BROOKS, Miss MAY, B.Sc., Neath County School; 14 Poplars Avenue, Neath, Glam.

1921 BROOKS, JOHN WALTER, B.Sc., South Shields High School for Boys; 5, Holmfield Avenue, South Shields, Co. Durham. Durham.

1935 BROOME, JAMES SPEARS, M.Sc., Headmaster of the Secondary School, Palmyra Square, Warrington, Lancs.

1935 BROSGALL, JACK, B.Sc., Woodhouse Secondary School, London, N.12; 16 Lincoln Road, East Finchley, London, N.2.

1936 BROWN, Miss ANNIE, B.Sc., Ashford High School, Kent; 39, Logwood Street, Blackburn, Lancs.

1926 BROWN, Miss DOROTHY, B.Sc., Girls' High School, Chesterfield, Derbyshire.

1935 BROWN, Miss ELLEN TAYLOR, M.A., Palmer's School for Girls, Grays; 50 Parker Road, Grays, Essex.

1928 BROWN, FREDERICK GEORGE WILLIAM, M.Sc., F.C.P., West Ham Secondary School; Strathmore, 25 Wellwood Road, Goodmayes, Essex.

1926 BROWN, FREDERICK WILLIAM, M.Sc., L.C.P., Spring Grove Secondary School, Isleworth; Ingleside, 80 College Road, Isleworth, Middlesex.

1935 BROWN, GEORGE, M.A., Dalry Secondary School, Ayrshire; 23 Gates Road, Lochwinnoch, Renfrewshire, Scotland.

1922 BROWN, JOHN THOMAS, M.A., B.Sc., The High School, North Berwick, East Lothian, Scotland.

1928 BROWN, MEREDITH WAYLAND, M.A., Bec School, Beechcroft Road, London, S.W.17; 62 Fairway, Carshalton Beeches, Surrey.

1935 BROWN, Miss MURIEL, B.A., Pendleton High School for Girls, Eccles Old Road, Salford, 6, Lancs.

1920 BROWN, THOMAS ARNOLD, B.A., M.A., B.Sc., F.R.S.E., Professor of Mathematics, University College of the South-West, Exeter, Devon.

1923 BROWNE, WILLIAM LAURENCE FRASER, M.A., Winchester College; Hawkins', Winchester, Hants.

1935 BROWNLEE, ROBERT WYNESS, M.A., Hamilton Academy; 10 West Scott Terrace, Hamilton, Lanarkshire, Scotland.

1927 BUCHANAN, JAMES, M.A., B.A., Perse School, Cambridge.

1922 BUCKLEY, ALFRED, M.A., Heathcote, Wellington College, Berks.

1937 BUCKLEY, Miss MARY LUCIE, B.Sc., Masonic School, Rickmansworth, Herts.

1930 BULL, GEORGE ARTHUR, B.Sc., 3 Marina Gardens, Felixstowe, Suffolk.

1935 BULLEN, GEORGE ARTHUR, B.A., Downhills Central School, Tottenham; Bracknell, Southgate Road, Potters Bar, Middlesex.

1902 BULLERWELL, JOHN WILLIAM, M.Sc., A.Inst.P., King's College, Newcastle-upon-Tyne.

1919 BURCHNALL, JOSEPH LANGLEY, M.C., M.A., Reader in Mathematics in the University of Durham; 1 Fieldhouse Terrace, Durham.

1928 BURDON, JOHN HALL, M.B.E., B.Sc., Head Master of The Downham L.C.C. Central School, Bromley, Kent; 79 Halesworth Road, Lewisham, London, S.E.13.

1927 BURKILL, JOHN CHARLES, M.A., Fellow and Tutor of Peterhouse; formerly Professor of Pure Mathematics in the University of Liverpool; 20 Chaucer Road, Cambridge.

1931 BURN, ERNEST WILLIAM, M.A., City of Bath (Boys') School, Bath, Somerset.

1930 BURNHAM, CHARLES EDWARD AKED, B.Sc., The County School, Whitby; Kettleness, Upgang Lane, Whitby, Yorks.

1935 BURNLEY, Miss SILVIA, B.A., Girls' Grammar School, Watford; 68, Prince's Avenue, Watford, Herts.

1936 BURR, MAX DE WHARTON, M.A., Headmaster, Belmont School, Clayton Wickham, Hassocks, Sussex.

1933 BURROW, STAFFORD MONTAGUE, B.Sc., Priory School, Shrewsbury; Mel Tor, Mytton Oak Road, Shrewsbury, Shropshire.

1926 BUSBRIDGE, Miss EVELYN MAY, B.A., Bromley County School for Girls; Haremere, Longdon Wood, Keston, Hayes, Kent.

1935 BUSH, FREDERICK JAMES, B.Sc., Gateway School, Leicester; 681 Loughborough Road, Birstall, Leicester.

1906 BUSHELL, WARIN FOSTER, M.A., F.R.A.S., Head Master of Birkenhead School, Birkenhead, Cheshire.

1936 BUTCHER, ARTHUR LEPINE, Birkdale Preparatory School, Broomhill, Sheffield, Yorks; 78 Wood Vale, London, S.E.23.

1918 BUTLER, Miss ANNIE KATHLEEN, M.A., Secondary School for Girls, Sydenham; 4, Park Mansions, Sydenham Park, London, S.E.26.

1926 BUTLER, Miss ELSIE GERTRUDE, B.A., The High School, Nuneaton; 30 Gipsy Lane, Nuneaton, Warwickshire.

1918 BUTLER, JAMES, M.A., B.Sc., County High School, Clacton-on-Sea; 48, Southcliffe Park, Clacton-on-Sea, Essex.

1937 BUTTERWORTH, Miss EVELYN, St. Mary's School, Colchester, Essex; Becontree, Brightlingsea, Essex.

1924 BUTTERWORTH, Miss FREDA, M.A., Camden School for Girls, London, N.W.5; Echomen, Harrowdene Road, North Wembley, Middlesex.

1919 BUXTON, ARNOLD, M.A., F.R.A.S., Head of Mathematics and Mechanics Department, The Technical College, Cardiff; Felton, 37 Heoldon, Whitchurch, Nr. Cardiff, Glam.

1923 CADMAN, GEORGE EDWIN, M.A., Boys' Grammar School, Keighley; Fair View, 226 Bradford Road, Riddlesden, Keighley, Yorks.

1910 CAIGER, Miss JESSIE ELLEN, B.A., County High School, Ilford; 74a, Anson Road, Cricklewood, London, N.W.2.

1918 CAIRD, Miss ELIZABETH MARGARET, M.A., Pendruccombe, Launceston, Cornwall.

1936 CAMPBELL, Miss JANETTE MARJORIE, B.Sc., Northgate School for Girls, Ipswich, Suffolk; Sannox, Yelverton, South Devon.

1914 CANTER, Miss EMMA, B.Sc., Eltham Hill School; 3 Balcaskie Road, Eltham, London, S.E.9.

1932 CAPES, Miss GWLADYS MARY, M.A., Training College, Bingley, Yorks; 132 Woodsley Road, Leeds, 2, Yorks.

1930 CAREY, RICHARD MEIN, M.A., Rugby School; Hillbrow, Barby Road, Rugby, Warwickshire.

1922 CARLESS, Miss FLORENCE DOROTHY, M.A., Mathematical Lecturer at Homerton College, Cambridge; 12 Harvey Road, Cambridge.

1922 CARPENTER, ALBERT GEORGE, B.Sc., A.K.C., The City Boys' School, Leicester; 39 St. Leonard's Road, Clarendon Park, Leicester.

1936 CARRINGTON, FREDERICK HOWARD, B.Sc., 97 Paxford Road, North Wembley, Middlesex.

1903 †CARSLAW, HORATIO SCOTT, Sc.D., D.Sc., Hon. LL.D., F.R.S.E., Emeritus Professor of Mathematics in the University of Sydney, New South Wales; Burradoo, New South Wales, Australia.

1930 CARTER, Miss ETHEL GRACE, B.Sc., The High School for Girls, Newport; 5 Woodville Road, Newport, Mon.

1927 CARTER, HAROLD, B.Sc., Munro College, Jamaica, British West Indies.

1928 CARTER, Miss MURIEL (Math. Trip.), Girls' High School, Dudley; Hawthorn Croft, Quinton, Birmingham.

1924 CARTWRIGHT, Miss MARY LUCY, M.A., D.Phil., University Lecturer in Mathematics, Fellow and Lecturer of Girton College; Glenmore, Sutton Courtenay, Nr. Abingdon, Berks.

1935 CATON, CYRIL THOMAS LEAR, M.A., M.Sc., The Grammar School, Alcester, Warwickshire.

1928 CAUNT, GEORGE WILLIAM, M.A., Reader in Mathematics, King's College, Newcastle-upon-Tyne; 59 Queen's Road, Monkseaton, Northumberland.

1936 CAUNT, PERCY BUCHANAN, B.Sc., Nantwich and Acton Grammar School; 151 Welsh Row, Nantwich, Cheshire.

1935 CAVE, ARTHUR RAYMOND, B.A., The Grammar School, Shaftesbury, Dorset.

1923 †CAVE-BROWNE-CAVE, Miss FRANCES EVELYN, M.A., F.R.A.S., 31 Storey's Way, Cambridge.

1933 CELESTINE, REV. BROTHER, St. Mungo's Academy, Glasgow; 48 Parson Street, Townhead, Glasgow, C.4.

1934 †CELIA, CUTHBERT WALTER, M.Sc., Northern Secondary School for Boys, Portsmouth, Hants.

1924 CHAFFER, FREDERICK THOMAS, B.Sc., Varndean School for Boys, Brighton, Sussex; 143 Preston Road, Brighton, Sussex.

1934 CHAMBERLAIN, Miss KATE SARAH, B.A., County Secondary School for Girls, Balmoral Road, Nottingham; 49 Forest Road, Nottingham.

1937 CHANNON, JOHN BREDIN, M.A., Rugby School; 50 Hillmorton Road, Rugby.

1931 CHAPMAN, A. P., B.Sc., Highbury County School; 11 Woodside Park Avenue, Whipps Cross, London, E.17.

1935 CHAPPELL, GEORGE ERNEST, M.Sc., County School, Bridgend; Lismore, 29 Wyndham Crescent, Bridgend, Glamorgan.

1936 CHAPPLE, MAURICE TREGEAR, M.Sc., Glanmôr Secondary Boys' School; Beechwood, 19, Sketty Avenue, Swansea, Glam.

1930 CHAPPLE, Miss SYLVIA TRYPHENA, B.Sc., Girls' County School, Aberdare, Glam.

1933 CHEOW, UNG KHEK, Anderson School, Ipoh, Perak, Malaya.

1933 †CHERRY, THOMAS MACFARLAND, B.A., Ph.D., Professor of Mathematics in the University of Melbourne, Melbourne, N.3, Victoria, Australia.

1922 CHEVALIER, REGINALD CHITTENDEN, M.A., Manchester Grammar School; 3 Fort Road, Sedgley Park, Prestwich, Manchester.

1936 CHICK, LEONARD HAROLD, B.Sc., Abbotsholme School, Rocester, Nr. Uttoxeter, Staffs.

1904 CHIGNELL, NORMAN JAMES, M.A., Charterhouse, Godalming, Surrey.

1934 CHILDS, PATRICK, M.A., The School, Shrewsbury.

1937 CHOPPING, Miss GERTRUDE, B.Sc., The County School for Girls, Cranmer Road, Mitcham, Surrey.

1915 †CHRISMAS, CHARLES HERBERT, B.A., Head Master of the Fort Street Boys' High School, Petersham, New South Wales, Australia.

1931 CHRISTISON, Miss MAY FRANCES, LL.A., St. Michael's, Bognor Regis, Sussex.

1930 CHUBB, BERTRAM JOSEPH, M.B.E., F.C.P., Head Master of H.M. Dockyard School, Devonport, Plymouth, Devon.

1935 CHUDLEIGH, Miss HILDA FLORENCE, B.Sc., M.Sc., Fairfield Secondary School, Bristol; 25, Seymour Road, Bishopston, Bristol, 7.

1915 CHURCH, ALBERT EDGAR ROBERT, M.A., D.Sc., Sir John Cass Institute, London; 26 Grasmere Road, Purley, Surrey.

1933 CHURCHILL, Miss MATTIE MILTON, B.Sc., Gelligaer County School for Girls, Hengoed, Glam.

1932 CHUTE, Rev. JOHN CHALONER, M.A., Eton College, Windsor, Berks.

1935 CIVIL, DOUGLAS EDWARD, B.Sc., Exmouth Grammar School; Vectis, Grange Avenue, Exmouth, Devon.

1932 CLAPTON, NATHANIEL LANGFORD, M.A., Glasgow Academy; 47 Cranworth Street, Glasgow, W.2.

1916 CLARK, Miss DOROTHY MARY, M.A., St. Swithun's School, Winchester; 24 Ranelagh Road, Winchester, Hants.

1919 CLARK, Miss EVELYN GRACE, B.A., Girls' Grammar School, Hitchin; 4 Nutleigh Grove House, Hitchin, Herts.

1920 CLARK, Miss JEANNETTE, B.Sc., Collegiate School for Girls, Beech Avenue, Blackpool; 29 Beech Avenue, Blackpool, Lancs.

1930 CLARK, JOHN WILLIAM, M.A., Northallerton Grammar School; Sonoma, L'Espec Street, Northallerton, Yorks.

1935 CLARK, WALTER, M.A., Royal Grammar School, High Wycombe, Bucks; Cissa, Totteridge Lane, High Wycombe, Bucks.

1930 CLARKE, EDWARD JOHNSON, B.Sc., The High School for Boys, Douglas, Isle of Man; Governor's Road, Oncham, Isle of Man.

1907 †CLARKE, FRANK, M.A., Head Master of Queen Elizabeth's School, Crediton, Devon.

1932 CLARKE, HAROLD GEORGE MICHAEL, M.A., Repton School, Derbyshire.

1936 CLARKE, JOSEPH, M.A., B.Sc., Buxton College, Derbyshire; 7 Wye Grove, Buxton, Derbyshire.

1937 CLARKE, LEONARD WILLIAM, M.A., Bishopsholt School, Hillingdon, Uxbridge; Sandane, Swakeleys Road, Ickenham, Uxbridge, Middlesex.

1916 CLARKE, Rev. SYDNEY HERBERT, M.A., St. John's College, Johannesburg, South Africa.

1931 CLAYTON, JOHN ALFRED, B.Sc., Manchester Central High School for Boys; Northgate, Shaftesbury Avenue, Cheadle Hulme, Cheshire.

1912 †CLAYTON, Miss ROSE ANNIE, B.A., The Grammar School, Burford, Oxfordshire.

1937 CLEMENTS, RONALD HARRY, B.A., Bournemouth School; 48 Wellington Road, Bournemouth, Hants.

1934 CLEMOW, JOHN, M.A., Purley County School; Hill Top, Bradmore Green, Old Coulsdon, Surrey.

1936 CLITHEROE, LLOYD, B.Sc., Willesden Technical College, Denzil Road, London, N.W.10.

1913 COATES, ERNEST WILLIAM, M.A., Inspector, Ministry of Education, Egypt; Turf Club, Cairo, Egypt.

1920 COATES, Mrs. NORA EVELINE, M.A., Gumley House, Isleworth; Araguaya, The Grove, Isleworth, Middlesex.

1930 COBB, RALPH HERBERT M.A., Malvern College; 9 The Lees, Great Malvern, Worcs.

1935 COBBAN, Miss NANCY LEE, B.Sc., Waterloo Park School for Girls; 10 Adelaide Terrace, Waterloo, Liverpool 22.

1924 †COCK, FRANCIS JOHN, 2 Lyndhurst Road, Wood Green, London, N.22.

1928 COCKRILL, GERALD WHITAKER, B.Sc., Brockenhurst County Secondary School; Green Ways, Balmer Lawn, Brockenhurst, Hants.

1935 COLEY, Miss WINIFRED MARY, B.A., Ladies' College, Cheltenham, Glos.

1926 COLLETT, Miss HERMINA MARY (Math. Trip.), St. Swithun's School, Winchester; Downside, West Town, Bristol.

1929 COLLIER, DAVID ERIC, M.C., M.A., B.Sc., Rector of the Morgan Academy, Dundee; 15 Fintry Place, Broughton Ferry, Angus, Scotland.

1937 COLLINSON, JOHN, B.A., Farnborough School, Holme Park, Sonning, Nr. Reading.

1936 COLOMBÉ, PAUL VICTOR AMOS, B.A., Gresham's School, Holt; Newlands, Kidmore End, Reading, Berks.

1918 COLTHURST, Rev. JOSEPH RIVERSDALE, M.A., Calary Rectory, Kilpedder, Greystones, Co. Wicklow, Irish Free State.

1930 COMBRIDGE, JOHN THEODORE, M.A., M.Sc., Lecturer in Mathematics, University of London, King's College; 58 Fengates Road, Redhill, Surrey.

1914 COMSTOCK, CLARENCE ELMER, A.B., A.M., Professor of Mathematics, Bradley Polytechnic Institute, Peoria, Illinois, U.S.A.

1936 CONE, Miss ZONA, M.Sc., County High School for Girls, Colchester; 52 Constantine Road, Colchester, Essex.

1928 COOK, Miss EILEEN, M.Sc., Kendrick Girls' School, Reading; 74 Cressingham Road, Reading, Berks.

1917 COOK, Miss HARRIET MARY, B.A., Edge Hill Training College, Ormskirk; 61, Bloomfield Avenue, Bath, Somerset.

1934 COOK, Miss WINIFRED MARGARET, B.Sc., Edgbaston High School, Birmingham; 36 Horn Park Lane, Lee, London, S.E.12.

1932 COOKE, Miss DOROTHY MILDRED, B.A., Priory County School for Girls; Dunelm, 44 Woodfield Road, Shrewsbury.

1936 COOKE, ERNEST EDWARD, M.A., Nevill Holt Preparatory School, Nr. Market Harborough, Leics.; 36 Botley Road, Oxford.

1930 COOKE, HUGH KENNETH, B.Sc., Saltley Secondary School, Birmingham; 88, Brockhurst Road, Ward End, Birmingham.

1915 †COOKE, WILLIAM INGRAM, M.A., 24 The Close, Norwich.

1914 COOKE, Miss WINIFRED A., B.Sc., High School for Girls, Slough; Yarningale, Pitts Road, Salt Hill, Slough, Bucks.

1933 COOMBS, Miss CONSTANCE EDITH, B.Sc., The Girls' High School, Middlesbrough, Yorks.

1930 COOPER, GEORGE HERBERT, M.Sc., The Grammar School, Burton-on-Trent; 20, Eton Road, Burton-on-Trent, Staffs.

1915 COOPER, Miss HILDA MARY, B.A., Girls' Grammar School, Maidstone, Kent.

1933 †COOPER, RALPH, M.A., Ph.D., Lecturer in Mathematics, Queen's University, Belfast; 15 King's Crescent, Knock, Belfast, Northern Ireland.

1936 COOTE, Miss ALICE MAY, M.A., Beckenham County School for Girls; 49 Kingshall Road, Beckenham, Kent.

1936 COPPOCK, STEPHEN WILLIAM, B.A., Bradford Grammar School; 3A High Street, Headington Quarry, Oxford.

1927 COPSON, EDWARD THOMAS, M.A., D.Sc., F.R.S E., Professor of Mathematics at University College, Dundee, Scotland.

1936 CORBETT, ARTHUR DENNIS, B.A., Heversham School, Westmorland; East View, Harts Bridge, Ketley, Wellington, Shropshire.

1937 COTTIS, JAMES GEORGE, B.Sc., 39 Monteagle Avenue, Barking, Essex.

1936 COTTRELL, WILLIAM FROOME, M.A., Lisvane School, Scarborough; 44 Prospect Mount Road, Scarborough, Yorks.

1935 COURCHÉE, HERBERT BLUETT, B.A., B.Sc., Raynes Park County School for Boys; Langdale, 38 Windsor Road, Worcester Park, Surrey.

1921 COWLEY, JOHN WILLIAM, B.Sc., Mathematical Lecturer, The City Training College, Collegiate Crescent, Sheffield, 10.

1936 COX, Miss DOROTHY AUDREY, 4 Hillside Avenue, Thornton Hill, Exeter, Devon.

1935 COX, HUBERT JACK, M.A., Magdalen College School, Oxford; 435, Alcester Road South, Wythall, Birmingham.

1931 COX, STEPHEN HENRY JOHNSON, B.A., Colet Court, London, W.6; 3 Palewell Park, Mortlake, London, S.W.14.

1923 COZENS, CHRISTOPHER JOHN, M.C., B.Sc., Peter Symonds School, Winchester; Wyke Lodge, Winchester, Hants.

1937 CRABBE, JOHN REGINALD, B.A., Christ's Hospital; Barnes "A," Christ's Hospital, Horsham, Sussex.

1913 CRACKNELL, Miss EDITH EMILY, M.A., The Girls' High School, Bedford; 106 Chaucer Road, Bedford.

1937 CRAIG, NORMAN JAMES FORSYTH, B.A., King Edward's School, Birmingham, 5; 323 Hagley Road, Edgbaston, Birmingham.

1920 †CRAIG, Miss PHYLLIS ELINOR, B.A., Varndean School for Girls, Brighton; Braedownie, Hove Park Way, Hove, Sussex.

1935 CRAIG, WILLIAM S., M.A., Eyemouth High School; 10, Houndlaw Park, Eyemouth, Berwickshire.

1935 CRAMP, ALFRED CECIL, Palmer's Boys' School, Grays, Essex.

1933 CRAMP, LESLIE JAMES, B.A., A.R.C.M., A.K.C., St. Olave's School, London, S.E.1; 68 Blenheim Park Road, South Croydon, Surrey.

1935 CRAWFORD, Miss ISBEL MARY, The Alice Ottley School, Worcester.

1902 †CRAWFORD, LAWRENCE, M.A., D.Sc., F.R.S.E., F.R.S.S.Af., late Fellow of King's College, Cambridge; Professor of Pure Mathematics in the University of Capetown, South Africa.

1923 CRIBB, Miss ESTELLE MURIELL, BRIDSON, M.A., Girls' Grammar School, Ipswich, Queensland; Gooloowan, Denmark Hill, Ipswich, Queensland, Australia.

1923 CRITCHLOW, JOHN, B.Sc., Bemrose School, Derby; Woodlands, Scarsdale Avenue, Allestree, Derby.

1933 CROCKER, ARTHUR JAMES ST. CLAIR, Erkenwald Senior Boys' School, Dagenham, Essex; 66 Stratton Drive, Barking, Essex.

1935 CROFTS, JOHN RAYMOND, B.A., Uppingham School; Greybarn, Uppingham, Rutland.

1932 CROMPTON, Miss ANNIE GAMBLE, M.A., Croydon High School for Girls; 8 Fryston Avenue, Croydon, Surrey.

1933 CROSLAND, LEONARD, M.C., B.Sc., A.K.C., Ulverston Grammar School; The Longcroft, Bardsea, Ulverston, Lancs.

1932 CROSLEY, GEORGE DUNCAN, F.C.S., University School, Southport, Lancs.

1927 CROSS, Miss GERTRUDE EMILY, B.A., Lady Eleanor Holles School, Hampton, Middlesex; 4 Copleston Road, East Dulwich, London, S.E.15.

1935 CROSS, ROBERT GORDON, B.A., Lord Wandsworth Agricultural College, Long Sutton, Basingstoke, Hants; 131, Lennard Road, Beckenham, Kent.

1925 CROWTHER, JAMES GERALD, 23 Russell Square, London, W.C.1.

1923 CULL, EDWARD CHARLES, B.Sc., Education Department, The University, Edmund Street, Birmingham, 3.

1924 CULLIS, Miss ELEANOR, B.A., Wallington County School for Girls, Carshalton; 16 Elmwood Road, West Croydon, Surrey.

1936 CUMBER, Miss ELLEN, M.A., St. Paul's Girls' School, Brook Green, London, W.6.

1933 CUMMINGS, JOHN, M.A., B.Sc., Whitgift School, Croydon; 17 Park Hill Court, East Croydon, Surrey.

1935 CUNNINGTON, WILLIAM JOHN, M.Sc., Woodhouse Grammar School, Nr. Sheffield; Ashdell Grove, Westbourne Road, Sheffield, 10, Yorks.

1933 CURNOW, HENRY JAMES, B.Sc., Technical College, Bradford, Yorks; 14 Pennithorne Avenue, Baildon, Shipley, Yorks.

1935 CURTIS, FREDERICK RONALD, B.Sc., The Technical College, The Butts, Coventry, Warwickshire.

1937 CYSTER, RAYMOND FREDERICK, B.A., Harrow County School for Boys; 12, Dickinson Avenue, Croxley Green, Herts.

1937 DAIN, FREDERICK RONALD, B.A., Loughborough College; Bethany, Fairmouth Drive, Loughborough, Leics.

1907 DAKIN, ALBERT, M.A., B.Sc., Head Master of The Grammar School, Stretford; 179 Urmston Lane, Stretford, Manchester.

1931 †DALAL, RUSTAN D., F.R.G.S., F.S.S., c/o Swiss Bank Corporation, 11c, Regent Street, Waterloo Place, London, S.W.1.

1921 DALTON, JOHN PATRICK, M.A., D.Sc., F.R.S.S.Af., Professor of Mathematics and Head of Department of Statistics and Actuarial Science, University of the Witwatersrand; P.O. Box 1176, Johannesburg, South Africa.

1924 DALTRY, CYRIL TETLOW, B.Sc., Roan School for Boys, Greenwich; 99 Maze Hill, London, S.E.10.

1928 DANIELS, HAROLD BENTLEY, B.Sc., A.M.I.Mech.E., Assoc.I.E.E., Constantine Technical College and Junior Technical School, Middlesbrough; Plas Mawr, Manchester Road, Four Lane Ends, Over Hulton, Bolton, Lancs.

1937 DARBY, Miss HELEN MARGARET, B.Sc., Ackworth School, Nr. Pontefract, Yorks; 14, Oakbrook Road, Endcliffe, Sheffield, 11.

1910 †DARE, ALBERT GEORGE, M.A., St. Lawrence College, Ramsgate, Kent.

1935 DARKE, GORDON PAUL, B.Sc., Tynemouth School, Tynemouth, Northumberland.

1925 DARLING, Miss MARGARET ROBERTSON, M.A., Wycombe Abbey, High Wycombe, Bucks; The Old Rectory, Trimley, Ipswich, Suffolk.

1936 DAVEY, Miss RUTH GERTRUDE, B.Sc., Uplands School, St. Leonards-on-Sea. Sussex.

1920 DAVIDSON, JAMES, M.A., Foyle College, Londonderry, Northern Ireland.

1930 DAVIES, ARTHUR BERTRAM, B.Sc., Canton High School for Boys, Cardiff; 37 Waterloo Gardens, Cardiff, Glam.

1937 DAVIES, ARTHUR GRANVILLE, B.Sc., High School for Boys, Newport Road, Cardiff; 7 St. Isan Road, Heath, Cardiff, Glam.

1921 DAVIES, BRYCHAN, Phillipstown School, New Tredegar; 33 School Street, Elliot Town, New Tredegar, Mon.

1932 DAVIES, JOSEPH NORMAN, B.Sc., Straits Settlements Education Department; Penang Free School, Penang, Straits Settlements.

1930 DAVIES, LEWIS HILLERION LORENZO, B.A., Technical College, Cardiff, Glam.

1931 DAVIES, Miss MARION, B.Sc., The High School for Girls, North Hill, Plymouth, Devon.

1926 DAVIES, Miss MARY JANE, B.A., Beverley High School; 26 Warton Avenue, Beverley, Yorks.

1920 DAVIES, NORMAN, B.Sc., Howard Gardens Boys' High School, Cardiff; 1 Meliden Road, Penarth, Glamorgan.

1937 DAVIES, STANLEY GEORGE, B.Sc., Southern Secondary School, Southsea; 8 Evelegh Road, Farlington, Portsmouth.

1925 DAVIES, SYDNEY, B.Sc., Queen Elizabeth's Grammar School, Carmarthen; Netherby, Myrddin Crescent, Carmarthen, South Wales.

1933 DAVIES, WILLIAM THOMAS, B.Sc., Port Talbot County School; 19 Grange Street, Port Talbot, Glam.

1929 DAVIS, ERNEST SAMUEL, B.Sc., Bishop Wordsworth's School, Salisbury; Uplands, Moberley Road, Salisbury, Wilts.

1934 DAVIS, Miss MARJORIE WINIFRED, B.Sc., Stafford Girls' High School; Mylon, Co-operative Street, Stafford.

1932 DAWSON, Miss SARAH ELIZABETH, B.Sc., The High School, High Wycombe; The Old Cottage, Speen, Princes Risborough, Bucks.

1935 DAY, Miss NORA HELEN, B.A., Guildford County School; 13 Thorn Bank, Onslow Village, Guildford, Surrey.

1928 DEAN, Miss JESSIE EMMA, M.A., Wimbledon County School for Girls; 16 Cyril Mansions, Prince of Wales Road, Battersea, London, S.W.11.

1936 DEAN, WILLIAM REGINALD, M.A., Trinity College, Cambridge.

1923 DEANE, FRANK SYDNEY, B.Sc., Queen Elizabeth's School, Kirkby Lonsdale; Windcroft, Kirkby Lonsdale, Westmorland.

1935 DEANE, HERBERT JAMES, B.A., Brentwood School; 29 Mount Crescent, Brentwood, Essex.

1937 DEANS, JOHN, M.A., Motherwell Secondary School; 19 Prospect Avenue, Cambuslang, Glasgow.

1926 DEANS, Miss WINIFRED MARGARET, M.A., B.Sc., Science Editor, Messrs. Blackie & Son, Ltd., Glasgow; 17 Stanhope Street, Glasgow, C.4.

1911 de CHAUMONT, Rev. THOMAS SANDFORD BLAKISTON FRANCOIS, M.A., The Parsonage, Nicosia, Cyprus.

1927 DEDICOAT, Miss DOROTHY ALICE, M.A., The Salt High School for Girls, Shipley; 45 Kirkstall Mount, Kirkstall, Leeds, Yorks.

1936 DENNEY, CYRIL WALTER, M.A., Headmaster, Eversfield Preparatory School; Eversfield, Solihull, Warwickshire.

1932 DENNIS, TREVOR, M.A., Head Master of the Hulme Grammar School, Alexandra Park, Manchester, 16.

1923 DENT, Miss EDITH GLADYS, B.A., Canton High School for Girls, Cardiff; 30 Rectory Road, Cardiff, Glam.

1927 DIAPER, Miss GLADYS, B.Sc., Skinners' Girls' School; 14 Glaserton Road, Stamford Hill, London, N.16.

1922 †DICK, ROBERT HAMILTON, M.A., F.R.G.S., F.R.S.G.S., South African College High School, Capetown; Achray, Milner Road, Rondebosch, Capetown, South Africa.

1927 DIGGLES, ROBERT EDWARD, B.Sc., F.R.A.S., The High School, Hanley, Stoke-on-Trent, Staffs.

1933 DITCHBURN, Miss MARGARET, B.Sc., High School for Girls, South Shields; 32, Milvain Avenue, Newcastle-upon-Tyne.

1933 DIXON, ARTHUR LEE, M.A., F.R.S., Waynflete Professor of Pure Mathematics in the University of Oxford and Fellow of Magdalen College, Oxford.

1910 DIXON, Rev. HERBERT HENRY, M.A., Dulwich College, London, S.E.21.

1935 DIXON, LLOYD, M.A., Monmouth School; Gezira, Hereford Road, Monmouth.

1902 DOBBS, FRANCIS WELLESLEY, M.A., Westbourn, Wentworth, Surrey.

1898 DOBBS, WILLIAM JOHN, M.A., Finlarig, 2, Alexandra Road, Andover, Hants.

1925 DOCKERAY, NORMAN ROBERT CULMORE, M.A., Harrow School; 4 West Hill Hall, Harrow-on-the-Hill, Middlesex.

1934 DOCKRAY, Miss FLORENCE ANN, B.Sc., City of Cardiff High School for Girls; 39 Church Road, Whitchurch, Nr. Cardiff, Glam.

1928 DODD, FREDERICK HENRY, L.R.C.P., M.R.C.S., F.G.S., Heatfield, Keston, Hayes, Kent.

1928 DOGHERTY, Miss ANNIE, Girls' Grammar School, Bradford, Yorks.

1928 DOGHERTY, Miss WINIFRED, B.A., Headmistress of Margaret Sewell School, Carlisle; 3 Beech Grove North, Stanwix, Carlisle.

1910 DOLAN, Rev. JOSEPH P., M.A., Ampleforth College, Yorks.

1914 DONALD, Miss E. MARIAN, B.Sc., Girls' High School, East London, South Africa.

1932 DONALD, Miss PRISCILLA THOMSON, M.A., Worcester City Secondary School for Girls; 13 The Hill Avenue, Worcester.

1930 DOOUSS, FREDERICK JOHN, B.A., B.Sc., Chigwell School, Essex.

1928 DOUGALL, JOHN, M.A., D.Sc., F.R.S.E., Scientific Editor to Messrs. Blackie & Son; 47 Airthrey Avenue, Glasgow, W.4.

1931 DOUGHTY, Miss MARGARET ANNA, B.Sc., High School for Girls, Bridlington; 3 Meadowfield Road, Bridlington, Yorks.

1921 DOUGLAS, ANDREW BRUCE, M.A., Gresham's School, Holt; Farfield, Holt, Norfolk.

1925 DOWDALL, Miss CONSTANCE ALICE, B.A., The High School for Girls, Luton, Beds.; Clevedon, 72, Friern Park, North Finchley, London, N.12.

1935 DOWN, Miss ETHEL MAUD, B.Sc., Copthall County School, Mill Hill; 47 Staverton Road, Brondesbury Park, London, N.W.2.

1933 DOWNING, HENRY JULIAN, B.Sc., Boys' High School, Trowbridge; 113, Bradley Road, Trowbridge, Wilts.

1919 DOWSETT, Miss MABEL ELIZA ANN (Sister MABEL, +O.H.P.), B.Sc., St. Hilda's School, Sneaton Castle, Whitby, Yorks.

1935 DOY, DUDLEY HOWARD, Minster Grammar School, Southwell, Notts.

1936 DRIVER, EDWIN H., Auckland Grammar School, New Zealand.

1935 DRONFIELD, JOHN, M.A., Worksop College, Notts.

1937 DUNBAR, DAVID SCOTT, M.A., B.A., Uppingham School; Ayston Road, Uppingham, Rutland.

1932 DUNBAR, Miss ELSIE A., B.A., County Secondary School, Southall, Middlesex; Cumberland Lodge, Ealing Common, London, W.5.

1937 DUNN, DENNIS, B.Sc., B.Eng., St. Francis Xavier's College, Liverpool; 24 Braunton Road, Liverpool, 17.

1923 DUNN, Miss MARGARET, B.Sc., Sandecotes School, Parkstone, Dorset.

1935 DURANT, BERTRAM, M.A., Chesterfield Grammar School, Derbyshire.

1922 †DURELL, CLEMENT VAVASOR, M.A., Winchester College; Meadow House, 27 Kingsgate Street, Winchester, Hants.

1933 DURSTON, Miss BERYL, B.A., High School for Girls, Denmark Road, Gloucester.

1937 EARP, Miss OLIVE MARY (Math. Trip.), South Shields High School for Girls; 65, Franklin Road, Bourneville, Birmingham.

1935 EASTWOOD, FRANK EDWARD, B.Sc., The Grammar School, Hebden Bridge, Yorks.

1935 EDGAN, JAMES ALLAN, M.A., B.A., F.R.A.S., Marlborough College, Wiltshire.

1920 EDINGTON, Miss ELSIE MAY, B.A., Parliament Hill School, London, N.W.5; 137 Makepeace Mansions, Highgate, London, N.6.

1933 EDINGTON, JAMES DUNCAN, B.Sc., The Training College, York.

1923 EDMUNDS, Miss EDITH JANE, B.Sc., Calder Girls' High School, Harthill Road, Liverpool; 6 Dudlow Drive, Liverpool, 18.

1910 †EDWARDS, Miss EDITH FLORENCE, M.A. (Math. Trip.), Head Mistress of the Fairfield High School for Girls, Nr. Manchester.

1926 EDWARDS, Miss ETHEL MARY, M.A., Head Mistress of James Allen's Girls' School, East Dulwich Grove, London, S.E.22.

1936 EDWARDS, Miss FRANCALIEN JOYCE HOLDEN, Whitehill Senior Girls' School, Chesham; Chilterns, Ridgeway Road, Hivings Hill, Chesham, Bucks.

1930 EDWARDS, HAROLD JAMES, B.Sc., County School, Tredegar, Mon.; Poulton House, Park Place, Tredegar, Mon.

1910 EDWARDS, JOHN STANLEY, B.A., Fettes College, Edinburgh.

1930 EDWARDS, Mrs. LUCY EMMA, B.A., Head Mistress of the Welsh Girls' School, Ashford, Middlesex.

1924 EGGINGTON, ALFRED THOMAS, M.C., B.Sc., A.R.C.S., Head Master of Loughborough Junior College; 64 Beacon Road, Loughborough, Leics.

1934 EGNER, WILLIAM EDWARD, B.A., B.Sc., Fellow of Armstrong College; Hymers College, Hull, Yorks.

1921 †EHRENBORG, GUSTAVUS BRAMWELL, M.A., Assistant Lecturer, City and Guilds (Engineering) College, London, S.W.7; Rahere, South Road, Chesham Bois, Bucks.

1935 ELDERTON, MERRICK BEAUFOY, B.A., Sherborne School; Abbeylands, Sherborne, Dorset.

1937 ELEN, LEONARD WILLIAM FREDERICK, M.Sc.; 15 Park Road, Twickenham, Middlesex.

1924 ELLIOTT, GEORGE ALLISON, B.Sc., Alderman Wood Secondary School, West Stanley, Co. Durham.

1936 ELLIOTT, KENNETH GEORGE IAN, Hurst Court, Ore, Hastings, Sussex; Priory Lodge, Chillerton Road, Tooting Bec, London, S.W.17.

1926 ELLIS, FREDERICK FREEMAN, B.Sc., King James' Grammar School, Knaresborough; Enderley, Wetherby Road, Knaresborough, Yorks.

1930 ELLSMOOR, Miss LUCY ANNIE, B.Sc., Clitheroe Royal Grammar School for Girls; 120 Pimlico Road, Clitheroe, Lancs.

1935 EMSDEN, PERCY ROBERT, B.Sc., Halesowen Grammar School, Worcs.; 3 Victoria Avenue, Quinton, Birmingham.

1929 ENGLEDOW, Miss GLADYS, M.A., Girls' High School, Wakefield, Yorks.; 4 Mayhill Road, Charlton, London, S.E.7.

1928 †EPERSON, Rev. DONALD BIRKBY, M.A., Sherborne School; Tantallon, Acreman Street, Sherborne, Dorset.

1925 ESAM, Miss EDITH ELSIE, B.A., Ipswich High School; 113 Rushmere Road, Ipswich, Suffolk.

1937 EVANS, Miss ELEANOR TRANTER, B.Sc., Kelvin, 43, Glenella Road, Llanelly, Carmarthen.

1912 EVANS, GEORGE W., A.B., 16 Beverley Road, Swampscott, Mass., U.S.A.

1935 EVANS, HERBERT FRANK, B.Sc., The Grammar School, Burnley, Lancs.

1922 †EVANS, Miss HILDA LUCY SILVESTER, M.A., County School for Girls, Camborne, Cornwall.

1937 EVANS, JOHN BRERETON, B.A., Taunton School, Somerset.

1935 EVANS, Miss KATHLEEN, MARIANNE, B.Sc., Newark High School; 28, Wellington Road, Newark, Notts.

1919 EVANS, REGINALD WILFRID, M.A., The Grammar School, Ilkley; Wendy, Bolling Road, Ben Rhydding, Yorks.

1913 EVANS, THOMAS HENRY THOMPSON, B.Sc., The Depperhaugh, Hoxne Cross, Diss, Norfolk.

1935 EVANS, Miss WINIFRED ALICE, B.A., Highbury Hill High School, Highbury, London, N.5.

1934 EVERINGTON, GEORGE FREDERICK, M.A., Brentwood School; Shenfield House, Brentwood, Essex.

1937 EVERITT, Miss ANNABEL JOAN, B.Sc., Devonport Secondary School for Girls, Plymouth; 39, Mostyn Road, Handsworth, Birmingham, 21.

1917 †EXTON, Miss GERTRUDE, M.A., Avery Hill Training College, Eltham; 214, Halfway Street Road, Sidcup, Kent.

1931 EXTON, ROBERT GORDON, B.Sc., Queen Elizabeth's Grammar School for Boys, Chesterfield Road, Mansfield, Notts.

1933 EYRE, CECIL GEORGE, B.A., Queen Elizabeth's Boys' Grammar School, Mansfield; Gurteen, Beech Hill Crescent, Mansfield, Notts.

1932 EYRE, PERCY JAMES, M.A., The Hulme Grammar School, Manchester.

1935 EYRES, NICHOLAS RIDLEY, B.A., Chard School, Chard, Somerset; Swale, Manor Brow, Keswick, Cumberland.

1926 FACON, Miss ELIZABETH MURIEL, M.A., Queen Elizabeth's Grammar School for Girls, Barnet, Herts.; 107, Watcombe Circus, Sherwood, Nottingham.

1937 FAGAN, BRIAN WALTER, B.A., 9, Constable Close, London, N.W.11.

1929 FAIRCLOUGH, Rev. HAROLD, St. Michael's College, St. John's Road, Leeds, 3, Yorks.

1935 FAIRES, WALTER GEORGE, B.Sc., Balgowan Central School, Beckenham, Kent; Fairview, Lingfield Road, Edenbridge, Kent.

1937 FAIRTHORNE, ROBERT ARTHUR, B.Sc., Scientific Officer, Royal Aircraft Establishment, Farnborough, Hants.; Kirk Michael, Hillfield Road, Farnborough, Hants.

1935 FANSHAWE, NIGEL HALFORD, M.A., Radley College, Abingdon, Berks.

1930 FARRAR, EDMUND, M.A., Wellington School, Somerset; 82, Preston Old Road, Cherry Tree, Nr. Blackburn, Lancs.

1937 FAULKNER, Miss ELEANOR GODWIN, B.Sc., Queen Elizabeth's Grammar School, Bromyard; Hill Crest, Bromyard, Hereford.

1910 FAWDRY, REGINALD CHARLES, M.A., B.Sc., 15, Clifton Park, Bristol, 8.

1910 FAWKES, WILFRID JAMES, B.Sc., West Suffolk County School, Bury St. Edmunds; 57, Out Risbygate, Bury St. Edmunds, Suffolk.

1913 †FAYERMAN, Miss WINIFRED MARIAN, M.A., Head Mistress of Tonbridge County School for Girls; Hestercombe, The Ridgeway, Tonbridge, Kent.

1912 FERGUSON, DONALD FRASER, M.A., Repton School, Repton, Derby.

1935 FERGUSSON, FRANK FAIRCHILD, M.Inst.C.E., F.G.S., Senior Executive Engineer, Public Works Department, Jodhpur, Rajputana, India; Principal Jodhpur Technical College.

1923 FERRAR, WILLIAM LEONARD, M.A., F.R.S.E., Hertford College, Oxford.

1924 FEWINGS, JOHN ALBERT, M.A., St. Andrew's School, Eastbourne, Sussex.

1925 FILON, LOUIS N. GEORGE, C.B.E., T.D., M.A., D.Sc., F.R.S., Goldsmid Professor of Applied Mathematics and Mechanics, University College, University of London; 68, St. Augustine's Avenue, South Croydon, Surrey. (President, 1937.)

1936 FINDLAY, ROBERT FLEMING, M.A., Paisley Technical College; Greenhead, Newmilns, Ayrshire, Scotland.

1936 FINKELSTEIN, JOSEPH, M.Sc., 24, Clifton Road, Herne Bay, Auckland, New Zealand.

1928 FINNEY, Miss ALICE BEATRIX DOUGLASS, M.A., Carlyle School, Chelsea; 79b, Harcourt Terrace, Redcliffe Gardens, London, S.W.10.

1936 FINNEY, DAVID JOHN, B.A., Clare College, Cambridge.

1931 FINNEY, ROGER RODEN, M.A., B.Sc., A.I.C., Head Master, County School, Milford Haven; 29, North Road, Milford Haven, Pembrokeshire.

1919 FIRKINS, HAROLD LUDLOW, M.A., H.M.I., Firlands, St. James' Lane, Winchester, Hants.

1903 FIRTH, FRED GARLAND, M.A., St. Olave's Grammar School, London, S.E.1; 95, Parliament Hill Mansions, Highgate Road, London, N.W.5.

1929 FISHER, CEDRIC HOWARD, M.A., Westminster School, Little Dean's Yard, Westminster, London, S.W.1.

1936 FISHER, Miss EDITH ALICE, B.A., Dorchester County School for Girls; 23, Mountain Ash Road, Dorchester, Dorset.

1916 FITZGERALD, ANTHONY NISBET, B.A., B.Sc., 40, Grove Avenue, Muswell Hill, London, N.10.

1926 †FLEMING, Miss ANNIE MILDRED, B.A., Girls' Grammar School, Ashby de la Zouch, Leicestershire.

1937 FLEMING, JACK, B.A., 354, Selly Oak Road, King's Norton, Birmingham.

1936 FLETCHER, ALAN, M.A., Ph.D., Department of Applied Mathematics in the University of Liverpool; 57, Upton Road, Birkenhead, Cheshire.

1929 FLETCHER, ALFRED, M.Sc., Heaton Secondary School, Newcastle-upon-Tyne; 20, Melrose Avenue, Monkseaton, Northumberland.

1934 FLETCHER, JOHN KAY, B.Sc., Crypt School, Gloucester; Charnwood, Lonsdale Road, Gloucester.

1927 FLETCHER, PHILIP, M.A., A.M., The College, Cheltenham, Glos.

1910 FLETCHER, WILLIAM CHARLES, C.B., M.A., late Fellow of St. John's College, Cambridge; Grove School, Hindhead; Longridge, Churt Road, Hindhead, Surrey.

1937 FLETCHER-JONES, ARTHUR AYLWIN, M.A., Dulwich College; 73, Calton Avenue, London, S.E.21.

1909 FLORENCE, Miss ISA CRAIG, M.A., County School for Girls, Enfield; 63, Talbot Road, Highgate, London, N.6.

1937 FLOYD, Miss RUBY FARVIS, B.Sc., 172, Randall Avenue, Cricklewood, London, N.W.2.

1913 FORDER, HENRY GEORGE, B.A., Professor of Mathematics, University College, Auckland, New Zealand.

1936 FORSTER, Miss ANNIE KIRK, B.Sc., The Church High School, Tankerville Terrace, Jesmond; 85, Grosvenor Avenue, Jesmond, Newcastle-upon-Tyne, 2.

1928 FOSTER, LUCAS, King Edward VI Grammar School, Totnes; Manor Croft, Totnes, South Devon.

1937 FOSTER, RONALD GEORGE, M.Sc., Gipsy Road Junior Mixed L.C.C. School; 261, Kent House Road, Beckenham, Kent.

1935 FOSTER, THOMAS HARTLEY, M.A., King Edward VI Grammar School, Louth, Lincolnshire.

1920 FOTHERGILL, GEORGE HAROLD, B.Sc., Henry Smith School, Hartlepool; Oriel House, Stockton Road, West Hartlepool, Co. Durham.

1931 FOULKES, HERBERT OWEN, M.Sc., County School, Port Talbot; 3, Tyfry Road, Margam, Port Talbot, Glam.

1925 FOULKES, THOMAS GEORGE, M.A., Swansea Grammar School; 1, Brynmill Crescent, Swansea, Glam.

1935 FOWLER, Miss ETHEL TUTTY, B.A., County Secondary School for Girls, Erdington; 65, Gravelly Hill North, Birmingham.

1928 FOX, CHARLES, M.A., D.Sc., Birkbeck College, University of London; 29, Briardale Gardens, Hampstead, London, N.W.3.

1930 FOX, RICHARD FRANK, Accountant General's Department, General Post Office, London, E.C.1; 75, Burney Avenue, Surbiton, Surrey.

1927 FRANKENBURG, Miss LUCIE, M.A., Bede Collegiate Girls' School, Sunderland; 4, St. George's Square, Sunderland, Co. Durham.

1926 FRASER, DUNCAN CUMMING, M.A., F.I.A., Wellington Buildings, The Strand, Liverpool.

1912 †FRASER, PETER, M.A., Reader in Geometry, The University, Bristol.

1929 †FRECHEVILLE, GEORGE, M.A., B.Sc., Windmill Hill Farm, Steeple Claydon, Bucks.

1937 FREEMAN, MORLEY HOWARTH, B.Sc., Beckenham County School for Boys; 16, Franklin Road, Penge, London, S.E.20.

1937 FRENCH, GEORGE, Morija Training Institution, Basutoland.

1922 FROST, TOM, B.Sc., 93, Lyndhurst Gardens, Finchley, London, N.3.

1922 FULFORD, REGINALD JAMES, M.Sc., B.Sc., King Edward's Grammar School, Five Ways, Birmingham; 71, Lonsdale Road, Harborne, Birmingham, 17.

1932 FULLER, ALEXANDER RICHARD BURNET, M.A., 5, Granville Road, Barnet, Herts.

1930 FUNSTON, Miss MARGARET FLORENCE, M.A., Richmond Lodge, Malone Road, Belfast, Northern Ireland.

1935 FYSON, HAROLD, M.A., Mercers' School, Holborn, London, E.C.1.

1910 GABBATT, JOHN PERCY, M.A., D.Sc., F.C.P.S., formerly Professor of Mathematics in Canterbury College, Christchurch, New Zealand; Durford Edge, Petersfield, Hants.

1936 GABRIEL, ROBERT MARK, M.A., The University, Leeds, 2, Yorks.

1922 GARDNER, GEORGE ANTHONY, M.Inst.Struct.E., Northern Polytechnic, Holloway; St. Anthony's, Barleycroft Green, Welwyn Garden City, Herts.

1916 GARNER, Miss WILHELMINA, M.Sc., M.Ed., The Whalley Range High School, Withington Road, Manchester.

1917 †GARNETT, Miss CHARLOTTE OCTAVIA, M.A., Clifton High School for Girls; 2, The Paragon, Clifton, Bristol, 8.

1937 GARRATT, Miss DOROTHY, B.A., Heaton Girls' Secondary School, Newton Road, Newcastle-upon-Tyne, 6.

1934 GARREAU, GABRIEL ARMAND, M.A., B.Sc., The Grammar School, Macclesfield; Merfield, Ivy Road, Macclesfield, Cheshire.

1910 †GARSTANG, THOMAS JAMES, M.A., 6, Holmesdale Road, Kew Gardens, Surrey.

1929 GARSTIN, Lieutenant-Colonel WILLIAM ARTHUR, C.B.E., 72, Courtfield Gardens, London, S.W.5.

1936 GASKELL, WILLIAM, B.Sc., Sturry Central School, Breadlands Lane, Sturry, Canterbury, Kent.

1925 GASKIN, Miss NORA F., B.Sc., Twickenham County School; Nevin, Burton's Road, Hampton Hill, Middlesex.

1935 GEARY, ALFRED, M.A., M.Sc., Northampton Polytechnic Institute, St. John Street, London, E.C.1.

1933 GENT, Miss PHYLLIS MARY (Math. Trip.), St. Paul's Girls' School, Brook Green; 91, Brook Green, London, W.6.

1935 GEORGE, CYRIL HENRY, B.Sc., Woolwich Central School for Boys, Bloomfield Road, Plumstead, London, S.E.18; 9, Newstead Avenue, Orpington, Kent.

1928 GERRARD, WILLIAM, A.M.I.Mech.E., Brantwood, Brook Lane, Timperley, Cheshire.

1923 GIBB, DAVID, M.A., B.Sc., F.R.S.E., University of Edinburgh; 45, Fountainhall Road, Edinburgh, 9.

1923 GIBBARD, CYRIL ARTHUR HUGH, B.A., Kimbolton Grammar School; Kimbolton House, Kimbolton, Hunts.

1909 †GIBBINS, Miss ETHEL MARY EUNICE, B.A., Northampton High School for Girls; 37, Billing Road, Northampton.

1909 †GIBBINS, NORMAN MARTIN, M.A., Head Master of the Central Foundation Boys' School, Cowper Street, London, E.C.2; Junior Army and Navy Club, Horse Guards Avenue, Whitehall, London, S.W.1.

1926 GIBBON, Miss DOROTHY (Math. Trip.), Rutherford College Girls' School, Newcastle-upon-Tyne; 30, Westacres Crescent, Newcastle-upon-Tyne, 5.

1925 GIBBONS, Miss DOROTHY MARY, B.A., Presbyterian Ladies' College, East Melbourne; 36, Downshire Road, Elsternwick, S.4, Victoria, Australia.

1928 GIBSON, Miss A. E., B.Sc., Girls' County School, Durham.

1936 GIBSON, GERALD EDWIN GLENFIELD, B.A., St. Marylebone Grammar School; Porthcothan, 52, Hillview Road, Hatch End, Middlesex.

1920 GIBSON, Miss MARY ESTELLE, B.Sc., St. Angela's High School, Forest Gate; 94, Osborne Road, Forest Gate, London, E.7.

1937 GILBERT, GEORGE HENRY, B.Sc., Palmer's School, Grays, Essex.

1914 GILES, Miss EDITH MARY, B.A., High School for Girls, Boston Avenue, Southend-on-Sea, Essex; 24, Cossington Road, Westcliff-on-Sea, Essex.

1920 GILHAM, CECIL WALTER, M.A., B.Sc., University of Leeds; 24, St. Chad's Avenue, Far Headingley, Leeds, Yorks.

1936 GILL, Mrs. MARJORIE MAUD, B.Sc., 120, Green Lane, Chislehurst, Kent.

1935 †GILLARD, Miss MABEL MARIA, B.Sc., Colston's Girls' School, Bristol; Redcliffe, Yatton, Nr. Bristol.

1914 GILLESPY, GEORGE THOMAS, A.M.I.Mech.E., F.R.S.A., Director of Instruction, International Correspondence Schools, International Buildings, 71, Kingsway, London, W.C.2.

1935 GILMOUR, WILLIAM ALEXANDER, B.A., late Colonial Office, Education Service; Stubbington House, Fareham, Hants.

1920 GIMSON, BASIL LOVIBOND, B.Sc., Bedales School; Five Oaks, Steep, Petersfield, Hants.

1908 GLAUERT, Miss ELSA, M.A., B.A., Head Mistress of the Girls' High School, Scarborough; 3, Harcourt Flats, Scarborough, Yorks.

1930 GLISTER, WILLIAM ERNEST, M.A., Derby School, Derby.

1935 GLOYNE, RONALD WESTLAKE, St. Norbert's Preparatory School, Robin Hood Lane, Sutton, Surrey; 32, Radbourne Road, Balham, London, S.W.12.

1929 GODBOLE, Professor MAHESHWAR SHANKAR, M.A., Sir Parashurambhan College, Poona, 2, Bombay, India.

1912 †GODDARD, HARRY, M.A., Nottingham High School; 63, Forest Road, Nottingham.

1936 GODFREY, CYRIL JOHN, B.Sc., The Modern School, Luton; Oakholme, 229, Ashcroft Road, Luton, Beds.

1928 GOLDSBROUGH, GEORGE RIDSDALE, D.Sc., F.R.S., F.R.A.S., Professor of Mathematics, King's College, Newcastle-upon-Tyne, 2.

1936 GOLDSMITH, Miss MARJORIE EDITH, B.Sc., Sheffield High School; Hylton, 179, Wembley Hill Road, Wembley Park, Middlesex.

1918 GOLDWIN, Miss MAY BEATRICE, M.A., County High School for Girls, Walthamstow; 8, Rectory Road, Walthamstow, London, E.17.

1933 GOODERHAM, Miss VERA WATTS, B.A., County Secondary School, Dalston; 1, Lion Gate Gardens, Richmond, Surrey.

1924 GOODING, SYDNEY GEORGE, M.A., Rowan, Little Plucketts Way, Buckhurst Hill, Essex.

1935 GORDON, CYRIL BERNARD, M.A., Tonbridge School, Tonbridge, Kent.

1935 GORDON, HORACE, B.Sc., The County School, Cardigan, South Wales.

1928 GORNALL, Miss ADELAIDE MARY (Math. Trip.), 23, Windsor Road, Bristol, 6.

1935 GOSLING, HAROLD WALTER, B.Sc., County Secondary School and Cumberland Technical College, Workington; 11, Hawkshead Avenue, Workington, Cumberland.

1912 GOSSET TANNER, ARTHUR SPENCER, M.A., 115, Radbourne Street, Derby.

1937 GOUDIE, CHARLES ARTHUR HAGUE, 97, Warren Road, Washwood Heath, Birmingham, 8.

1932 GOVER, DONALD FRANK, B.Sc., The Grammar School, Retford; 75, London Road, Retford, Notts.

1935 GRANDORGE, JOHN RICHARD, M.A., Towcester Grammar School; 20, Addison Terrace, Towcester, Northants.

1932 GRATTAN-GUINNESS, GERALD HENRY, B.A., B.Sc., A.K.C., Holme Valley Grammar School, Henley, Huddersfield; University of London Club, 21, Gower Street, London, W.C.1.

1928 GRAY, ALEXANDER HENDRY, M.A., Aberdeen Grammar School; 41, Rubislaw Park Crescent, Aberdeen.

1935 GRAY, Miss VIVIEN LANDON, B.A., Haberdashers' Aske's Girls' School, Acton; 116, Lynton Road, Acton, London, W.3.

1921 GREAVES, Miss MARY HELENA, B.A., High School for Girls, Hereford; Brockenhurst, Church Road, Hereford.

1936 GREEN, ARTHUR ROMNEY, B.A., 3, Bridge Street, Christchurch, Hants.

1923 GREEN, HENRY GWYNEDD, M.A., University College, Nottingham; Lucknow, 3, Humber Road, Beeston, Nottingham.

1927 GREEN, Miss MARGARET EVELYN, M.A., Charles Edward Brooke School for Girls, Halsmere Road, Camberwell, London, S.E.5.

1924 GREEN, STANLEY LAWSON, M.Sc., Queen Mary College, University of London; Rosemary, Leasway, Westcliff-on-Sea, Essex.

1906 GREENE, Miss ELIZABETH, M.A., Head Mistress of Bolling High School, Bradford; 40, Mannville Terrace, Bradford, Yorks. (Hon. Secretary, 1908-1909.)

1937 GREENHALGH, ROBERT, B.Sc., 150, Market Street, Tottington, Bury, Lancs.

1935 GREENWOOD, Miss HANNAH, B.Sc., Penzance County School for Girls; Ellan Vamin, Lidden Estate, Penzance, Cornwall.

1920 GREENWOOD, Miss IDA FLORENCE LEYTON, B.Sc., Church Close, St. Peter's Road, Lowestoft, Suffolk.

1922 †GREENWOOD, THOMAS, M.A., Ph.D., L.ès L., O.T., F.R.G.S., Officier d'Académie; Birkbeck College, University of London, Bream's Buildings, Fetter Lane, London, E.C.4; 21, Gower Street, London, W.C.1.

1918 GREGORY, BERNARD CHARLES, B.Sc., Municipal Technical College, Halifax; Wyngarth, Bridle Style, Shelf, Halifax, Yorks.

1937 GREGORY, ROBERT KENNETH, B.A., Queen Elizabeth's Grammar School, Blackburn; 46, Adelaide Terrace, Blackburn, Lancs.

1936 GRENFELL, DENIS ARTHUR, M.A., Tonbridge School; 20, Dry Hill Road, Tonbridge, Kent.

1928 GRIFFITH, IDWAL OWAIN, M.A., Fellow and Tutor of Brasenose College; 37, Banbury Road, Oxford.

1908 GRIFFITH, Miss MARGARET JANE, M.A., Head Mistress of the Dalston County Secondary School; 24, Putney Hill, London, S.W.15.

1937 GRIFFITH, MEIRION DAVID, B.A., Brambletye, East Grinstead, Sussex; 31, Rudall Crescent, Hampstead, London, N.W.3.

1932 GRIFFITHS, Rev. THOMAS TURNER, M.A., 15, Merton Road, Southsea, Hants.

1924 GRIGG, DONALD RICHARDSON, M.A., St. John's School, Leatherhead, Surrey.

1937 GRIMSHAW, Miss MARGARET ELEANOR, M.A., Newnham College, Cambridge.

1936 GRINHAM, R., M.A., Head Master of Ruzawi School (Diocesan Preparatory School for Boys), Marandellas, Southern Rhodesia, South Africa.

1919 GRISMAN, Instructor-Commander J. R., R.N., B.A., Fir Cottage, Park Way, Camberley, Surrey.

1935 GROCOCK, THOMAS ALFRED, B.Sc., King Edward VI School, Stourbridge, Worcs.

1913 †GRUNDY, A. M., M.A., Snowdenham, Boar's Hill, Oxford.

1922 GRUNDY, Miss NORA MURIEL, B.A., Girls' Grammar School, Barton Road, Torquay, Devon.

1924 GUILBERT, WILLIAM FRANK, B.A., Waverley Secondary School, Small Heath, Birmingham; 10, Ferndale Road, Hall Green, Birmingham.

1936 GUILLEBAUD, PETER DELABERE, B.A., Seaford College; 43, Parkside, Cambridge.

1935 GURRY, Miss HILDA MAUDE, M.Sc., Tottenham High School, London, N.17; 93, Peterborough Road, Fulham, London, S.W.6.

1933 †GUTHRIE, WILLIAM GILMOUR, M.A., Ph.D., F.R.S.E., Professor of Mathematics in Magee University College, Londonderry, Northern Ireland.

1924 GUTTRIDGE, Miss ADA, B.Sc., Girls' County High School, Leytonstone; 28, Clevedon Mansions, Lissenden Gardens, London, N.W.5.

1902 GWATKIN, Miss ETHEL RUTH, B.A., M.A., Head Mistress of Streatham Hill High School, Wavertree Road, Streatham Hill, London, S.W.2. (Hon. Secretary, 1910-11.)

1920 †GWILLIM, Miss EDITH MARIAN, B.Sc., 52, Bradford Road, Shipley, Yorks.

1916 HAGOPIAN, KRIKOR HRAND, B.Sc., The Edinburgh Academy; 88, Milton Road West, Portobello, Edinburgh, Midlothian.

1935 HADLAND, FRANK SHIRLEY, M.A., Shrewsbury School; 40, The Schools, Shrewsbury.

1931 HALL, Miss AMY LILIAN, B.Sc., Bedford College, University of London; 87, Grove Avenue, Muswell Hill, London, N.10.

1937 HALL, Miss BARBARA, B.Sc., Wirral County School for Girls, Bebington, Cheshire; 3, Court Oak Road, Harborne, Birmingham, 17.

1926 HALL, Miss ELIZABETH EMMA, Atherley School, Southampton; Whitcombe, Kellett Road, Southampton.

1911 HALL, Miss EMMA, formerly of Edgbaston High School for Girls; 14, Manor Road, Tankerton, Kent.

1929 HALL, ERIC REGINALD, M.A., Cranleigh School; High Hollicks, Cranleigh, Guildford, Surrey.

1920 HALL, FRANK GARDNER, M.A., Head Master of the Grammar School, Ashton-in-Makerfield, Wigan, Lancs.

1921 HALL, PERCY LAURANCE, B.A., Simon Langton School, Canterbury; Prestonbury, 26, Nunnery Road, Canterbury, Kent.

1933 †HALL, THOMAS WALTER, M.A., B.Sc., B.Sc.(Eng.), A.R.C.Sc.I., Lurgan Technical Institute, Windsor Avenue, Lurgan, Co. Armagh, Northern Ireland.

1935 HALLIDAY, JOHN A., M.A., Dumfries Academy, Dumfriesshire, Scotland.

1937 HALLUM, Miss KATHLEEN CAMERON, M.A., The Training College, Swansea, Glam.

1930 HAMAND, Miss TERESA MAUDE, B.A., Sutton High School; 6, The Close, South Rise, Carshalton Beeches, Surrey.

1934 HAMILL, CLAUD, B.Sc., Secondary School, Gateshead; Wingrove, Kell's Lane, Low Fell, Gateshead-on-Tyne, Co. Durham.

1936 HAMILTON, JAMES HUME, B.Sc., Central School for Boys, Richmond, Surrey; 12, Blandford Avenue, Whitton, Middlesex.

1931 HAMLEY, HERBERT RUSSELL, M.A., M.Sc., Ph.D., Professor of Education in the University of London, Institute of Education, Southampton Row, London, W.C.1.

1918 HAMMOND, Miss MARJORIE, B.A., Head of the Birmingham University Education Department (Women), 1 and 2, Great Charles Street, Birmingham; 33, Frederick Road, Edgbaston, Birmingham.

1932 HAMPSON, Miss MARIE, B.Sc., Hornsey High School; Flat 5, 87, Guildford Street, London, W.C.1.

1911 HANCOCK, Miss ETHEL MARY, B.Sc., Yenching University, Peiping West, China.

1937 HARBISHER, SYDNEY, B.Sc., The Friends' School, Lancaster; Thorneycroft, Fairfield Road, Lancaster.

1925 HARDCASTLE, Miss LUCY EMMA, M.Sc., Holly Lodge High School for Girls, Smethwick, Staffs; Fernley, Hardwick Road, Streetly, Sutton Coldfield, Birmingham.

1935 HARDIE, JOHN ANDREW, M.A., B.Sc., Daniel Stewart's College, Edinburgh.

1937 HARDING, JAMES WILLIAM, County School, Denbigh; Branksome Dene, Rhyl Road, Denbigh, North Wales.

1913 HARDINGHAM, CHARLES HENRY, M.A., St. George's School, Harpenden; St. Helier, Ox Lane, Harpenden, Herts.

1934 HARDY, Mrs. ANNA ELIZABETH THURSTON, M.A., 32, Drayton Green, London, W.13.

1936 HARDY, Miss HETTIE, M.A., The Training College, Darlington, Co. Durham.

1928 HARINGTON, Sir RICHARD DUNDAS, Bart., The Brook, Lower Howsell, Malvern Link, Worcs.

1936 †HARISON, EDWARD LANCELOT, B.Sc., St. John's College, Johannesburg, Transvaal, South Africa.

1925 HARMER, JOHN WILLIAM, M.A., F.R.A.S., Headmaster, Torquay Grammar School; Croyton, Teignmouth Road, Torquay, Devon.

1935 HARON, THOMAS K., B.Sc., Boys' High School, Falcon Street, North Sydney, New South Wales, Australia.

1917 HARRIES, Miss NESTA, Head Mistress of Chantry Mount School, Bishop's Stortford, Herts.

1930 HARRIS, JOSEPH BASTABLE, M.C., M.A., King's School, Canterbury; Holme House, 20, Old Dover Road, Canterbury, Kent.

1921 HARRIS, PERCY JOSEPH, B.Sc., F.R.A.S., Grammar School of King Edward VII, Market Harborough; Hillcroft, Shrewsbury Avenue, Market Harborough, Leics.

1921 HARRISON, Miss ELSIE (Math. Trip.), Sydenham High School; 18, Kingscote Road, Croydon, Surrey.

1935 HARRISON, Miss GRACE, B.A., M.A., Mill Mount Secondary School, York· The Croft, Marske Mill Lane, Saltburn-by-the-Sea, Yorks.

1937 HARRISON, Miss MARJORIE WHITAKER, B.Sc., Pate's Grammar School for Girls, Cheltenham; 4, St. Mary's Street, Clitheroe, Lancs.

1936 HART, CHARLES CLIFFORD, B.Sc., 2, Chez Nous Avenue, West Hartlepool, Co. Durham.

1919 HART, Miss D., Regent Street Intermediate Girls' School, Plymouth; 27, Mildmay Street, Plymouth, Devon.

1932 HARTREE, DOUGLAS RAYNER, M.Sc., Ph.D., F.R.S., Beyer Professor of Applied Mathematics in the University of Manchester; 1, Didsbury Park, Didsbury, Manchester.

1932 HARTWELL, Miss WINIFRED A., B.A., Streatham Hill High School; 30, Lawrie Park Road, Sydenham, London, S.E.26.

1912 HARVEY, FRANCIS WILLIAM, M.A., B.Sc., Battersea Polytechnic; 39, Calton Avenue, Dulwich Village, London, S.E.21.

1937 HARVEY, Rev. LESLIE FRANCIS, M.A., M.Sc., Shrewsbury School; Rad Cottage, Ridgebourne Road, Shrewsbury.

1937 HARWOOD, Miss MARY KATHARINE BEAUCHAMP, B.Sc., M.A., M.Sc., Providence Convent, Wood Green, N.22; 32, Brondesbury Park, London, N.W.6.

1924 HASKELL, HAROLD NOAD, M.A., Head Master of Harrison College, Barbados, British West Indies.

1935 HASLAM-JONES, UGHTRED S., M.A., D.Phil., Lecturer in Pure Mathematics, University of Liverpool; Rankin Hall, 44, Ullet Road, Liverpool, 17.

1920 †HASSÉ, HENRY RONALD, M.A., D.Sc., late Fellow of St. John's College, Cambridge; Professor of Mathematics in the University of Bristol; The University, Bristol.

1933 HATHAWAY, Miss ELSIE ROSE, B.A., Ealing County Girls' School; 11, Kent Gardens, Ealing, London, W.13.

1921 HATLEY, ALFRED JOHN, M.A., City and Guilds (Engineering) College, Imperial College, South Kensington, London, S.W.7; 28, Folkestone Road, London, E.17.

1930 HATTAM, MORLEY, B.Sc., The Boys' Blue School, Wells, Somerset.

1928 HAVELOCK, THOMAS HENRY, M.A., D.Sc., F.R.S., Professor of Mathematics, King's College (University of Durham), Newcastle-upon-Tyne.

1937 HAWES, CHARLES GODFREY, B.Sc., St. Helen's College, Southsea, Hants; 13, Park Road, Ryde, Isle of Wight.

1922 HAYDEN, HAROLD ARTHUR, M.Sc., D.Sc., Head of the Mathematical Department, Battersea Polytechnic, London, S.W.11; 37, Riverdale Gardens, Twickenham Park, Middlesex.

1928 HEADFORD, Miss HILDA CATHERINE, B.Sc., Whitley and Monkseaton High School for Girls, Whitley Bay, Northumberland.

1924 HEATH, ARTHUR CHRISTOPHER, M.A., St. Paul's School; 59, East Sheen Avenue, London, S.W.14.

1910 HEATH, Sir THOMAS LITTLE, K.C.B., K.C.V.O., Sc.D., Hon.D.Sc., Hon. Litt.D., F.R.S., F.B.A., Hon. Fellow of Trinity College, Cambridge; 64, Bedford Gardens, Kensington, London, W.8. (President, 1922–1923.)

1898 HEATON, WILLIAM HASLAM, M.A., M.I.E.E., Professor Emeritus, University College, Nottingham; 19, Lenton Road, Nottingham.

1892 HEAWOOD, PERCY JOHN, M.A., D.C.L., Professor of Mathematics in the University of Durham; High Close, Hollinside Lane, Durham.

1913 HENDERSON, FREDERICK WILLIAM, B.A., B.Sc., The Grammar School, Chorley, Lancs.

1931 HENDERSON, JAMES, M.A., B.Sc., Ph.D., University of London, King's College; 99, Hayes Way, Beckenham, Kent.

1924 HENNESSEY, FRANCIS ANTHONY CARROL, B.Sc., Industrial High School, Central Technical College, Brisbane, Queensland, Australia.

1933 HERMAN, Miss MAUD ELEANOR AMY, St. Leonards School, St. Andrews, Fife, Scotland.

1924 HERN, Miss EMILY ADA, B.Sc., Wyggeston Grammar School for Girls; 9, Salisbury Road, Leicester.

1936 HESSELGREAVES, JOHN WAINWRIGHT, M.A., B.Sc., Roundhay School (Boys), Leeds; 12, Chandos Avenue, Leeds, 8, Yorks.

1935 HEWARD, Miss DAISY ANNIE, B.Sc., Girls' Grammar School, Plashet Grove, East Ham, London, E.6.

1937 HEWINS, Captain VICTOR ST. GEORGE, Pencarreg, Barmouth, N. Wales.

1918 HEWITSON, Miss FLORENCE, West House School, Edgbaston, Birmingham; 86, Wentworth Road, Harborne, Birmingham, 17.

1925 HEWLETT, Miss CATHERINE GRACE, B.Sc., Tottenham High School, London, N.17; 18, Bracken Gardens, Barnes, London, S.W.13.

1931 HEYS-JONES, Miss MARJORIE BEATRICE, M.A., Copthall County School, Mill Hill, London, N.W.7; 4, St. Leonards Road, Ealing, London, W.13.

1912 HEYWOOD, HORACE BRYON, D. ès Sc. Math. (Paris), B.Sc., Civil Service Commission, Burlington Gardens, London, W.1.

1929 HEYWOOD, Miss RACHEL MARJORY, M.A., Sherborne School for Girls, Dorset; 35, Parkhills Road, Bury, Lancs.

1931 HICKS, Miss HILDA RUTH, B.Sc., Woking County Girls' School; 48, Chertsey Road, Woking, Surrey.

1934 HICKS, JOSEPH EDWIN, B.Sc., Head Master of the Intermediate School, Darlaston, Staffs; Netherhall, Bescot Road, Walsall, Staffs.

1935 HILL, CHARLES HORACE, M.A., Moseley Secondary School, Birmingham, 13.

1936 HILL, JOHN GROSVENOR, Amesbury School, Hindhead, Surrey.

1928 HILL, Rev. THOMAS HAYDN WARD, M.A., Llandovery College; Cerrig Cottage, Llandovery, Carmarthenshire.

1930 HILLS, FREDERICK ARTHUR, M.Sc., University College School, Frognal, Hampstead, London, N.W.3.

1923 HINCKLEY, ARTHUR, M.C., B.A., M.Sc., King Edward VI Grammar School for Boys, Camp Hill, Birmingham, and Birmingham Midland Institute; 237, Wake Green Road, Moseley, Birmingham, 13.

1931 HINDLEY, JOHN PEAR, M.Sc., Manchester Central High School; Becton, Thorn Road, Bramhall, Stockport, Cheshire.

1929 HITCHMAN, Miss KATHERINE ANNIE, (Math. Trip.), Putney County Secondary School; Mayfield, 24, Holenbush Road, Putney, London, S.W.15.

1930 HOARE, Miss KATHERINE NANCY HOLDEN, M.A., County Girls' School, Harrow; 5, Gerard Road, Harrow, Middlesex.

1926 HODGETTS, WILLIAM JOSEPH, M.A., Merchant Taylors' School; 46, Blenheim Road, North Harrow, Middlesex.

1920 †HODGSON, HAROLD BLACKLIN, M.A., The Grammar School, Chesterfield; 5, Brookside Bar, Chesterfield, Derbyshire.

1924 HODGSON, OWEN, A.C.G.I., The Grange School, Matfield, Kent; Worth Cottage, Broadstairs, Kent.

1927 †HOGG, Madame KATHLEEN BARBARA, B.A., Convent of the Sacred Heart, Roehampton, London, S.W.15.

1926 HOLDEN, ARTHUR, M.A., B.Sc., Head Master of Queen Elizabeth's Grammar School, Blackburn, Lancs.

1922 HOLDEN, JOSEPH ALDRIDGE, M.A., F.R.A.S., F.I.H., F.R.H.S., Head Master of the Grammar School, Normanton, Yorks.

1935 HOLFORD, ERNEST WILFRID, B.A., Eggars Grammar School, Downs View, Anstey Mill Lane, Alton, Hants.

1927 HOLGATE, Miss FLORENCE MABEL, B.Sc., Levenshulme High School for Girls, Crossley Road, Manchester.

1930 HOLGATE, Miss GLADYS AMELIA, B.Sc., Cirencester Grammar School; Bowerhill, St. Andrew's Road, Deal, Kent.

1918 HOLLINSHEAD, Miss ELEANOR, B.Sc., St. George's School for Girls, Edinburgh; 4, India Street, Edinburgh, 3.

1936 HOLLISTER, Mrs. ETHEL, M.Sc., Bedales School, Petersfield, Hants.

1923 HOLLOWELL, Miss G. A., Head Mistress of the County High School, Falmouth, Cornwall.

1924 HOLLOWELL, PATRICK WILLIAM CECIL, B.A., Bodeites, Charterhouse, Godalming, Surrey.

1933 HOLMAN, Miss ELLA MARJORIE, M.Sc., Manchester High School for Girls; Nevin, Nursery Road, Prestwich, Manchester.

1899 HOLMES, HERBERT THOMAS, O.B.E., M.A., H.M.I., Russettings, Ringley Park Avenue, Reigate, Surrey.

1933 HOLMES, ROBERT, M.Sc., West Ham Secondary School; 40, Boleyn Road, Forest Gate, London, E.7.

1929 HOME, MAURICE, B.A., M.Sc., Lecturer in Physics and Applied Mathematics, University of Bishops College, Lennoxville, P.Q., Canada.

1911 HOMER, JOHN BEARDSMORE, B.Sc., A.R.C.Sc., Loughborough College, Loughborough; 48, Stretton Road, Leicester.

1928 HONAN, THOMAS ANDREW, B.Sc., Cardinal Vaughan School, Kensington; 86, Horn Lane, Acton, London, W.3

1919 HOOKE, Miss MILDRED ALICE, M.A., Head Mistress of the Girls' Grammar School, Bradford, Yorks.

1933 HOOPER, JOHN HENRY, M.Sc., Bec School, Beechcroft Road, Tooting, London, S.W.17.

1936 HOPE, CYRIL, B.Sc., Wade Deacon Grammar School, Widnes, Lancs.; 81, Hamilton Street, Atherton, Manchester.

1937 HOPE, DENYS CHAMBERS, Birkrigg, Worcester Road, Stourbridge, Worcs.

1926 HOPE, JOHN HUMPHREY, M.A., 16, Lloyd Square, London, W.C.1.

1917 HOPE-JONES, WILLIAM, B.A., Eton College, Windsor, Berks.

1935 HORN, REGINALD BRUCE, B.Sc., Wirral Grammar School; 42, Prince's Avenue, Eastham, Wirral, Cheshire.

1920 HORNBY, Miss CLARA, B.Sc., The Training College, Ripon, Yorks.

1923 HORNER, Miss BERTHA, M.A., St. Winifred's, Llanfairfechan, N. Wales; Oakfield, Heaton, Bolton, Lancs.

1934 HORSLEY, SIDNEY GILBERT, M.A., M.Sc., 29, First Avenue, Gillingham, Kent.

1930 HOSEGOOD, GEORGE FRANK, B.Sc., Heanor Secondary School, Heanor, Notts; Shaldon, Codnor, Derbyshire.

1917 HOWARD, BASIL ALVIN, M.A., B.A., Head Master of Addey and Stanhope School, New Cross, London; Combe Bank Wood, Brasted, Kent.

1917 HOWARD, WILLIAM HARRY, M.A., King Henry VIII School, Coventry; 28, Earlsdon Avenue, Coventry, Warwickshire.

1937 HOWDEN, Miss JOAN ELLEN, B.Sc., Ladies College, Cheltenham; Christ Church Vicarage, Richmond, Surrey.

1933 HOWELL, Miss FRANCIS MARIE, M.Sc., High School for Girls, Ripon Yorks.; 162, Lightwoods Hill, Warley Woods, Birmingham.

1934 HOWELL, HUBERT VICTOR, B.Sc., Goldbeaters' Senior School, Burnt Oak, Middlesex; North Creake, Fakenham, Norfolk.

1930 HOWELL, WILLIAM GRAHAM, M.Sc., Ph.D., Principal of the Mining and Technical Institute, Neath; Hathaway, Dynevor Avenue, Neath, Glam.

1931 HOWELLS, EMRYS, M.Sc., Head Master of Ferndale Secondary School; 7, Darran Terrace, Ferndale, Rhondda, Glam.

1930 HOYLE, Miss RACHEL, B.Sc., Municipal Secondary School, Great Moore Street, Bolton; 98, Park Road, Bolton, Lancs.

1936 HUDSON, Miss EDITH, B.Sc., Newport (Mon.) Secondary School for Girls; 14, Burns Street, Padiham, Lancs.

1909 †HUDSON, Miss HILDA PHOEBE, O.B.E., M.A., Sc.D., 24, Park Drive, London, N.W.11.

1899 HUDSON, JAMES FRANK, M.A., B.Sc., Principal of the Technical College, Huddersfield, Yorks.

1933 HUGHES, Miss ALICE ELIZA MARY, B.A., Westcliff High School for Girls; 65, Crowstone Road, Westcliff-on-Sea, Southend, Essex.

1935 HUGHES, LEWIS, B.Sc., County School, Bethesda; Bronallt, Tregarth, Bangor, North Wales.

1928 HUGHES, Miss MARGARET SARAH, M.A., Morpeth High School, Morpeth, Northumberland.

1919 HUGHES, REGINALD THOMAS, M.A., Harrow School; Grove Hill House, Harrow-on-the-Hill, Middlesex.

1936 HUGHES, WILLIAM, B.Sc., Caerphilly Senior Boys' School, Glam.; 52, Grosvenor Street, Canton, Cardiff, Glam.

1936 HULL, LEWIS WILLIAM HALSEY, M.A., St. Faith's School, Trumpington Road, Cambridge.

1932 HUMPHREY, CHARLES ARTHUR, B.A., Christ's Hospital, Horsham, Sussex; Landsdowne, Hawthorn Lane, Wilmslow, Manchester.

1926 HUNTER, COLIN BOORER GARRETT, M.A., Winchester College; Morshead's, Winchester, Hants.

1936 HUNTER, WILLIAM, M.A., B.Sc., The College of Technology, Sackville Street, Manchester.

1921 HURD, HARRY WALLIS, B.Sc., Minchenden Secondary School, Southgate, N.14; Spinney, Bourne Hill, Palmers Green, London, N.13.

1930 HUTSON, Miss MAY, B.A., County School for Girls, Lewes; Holmcroft, Southdown Avenue, Lewes, Sussex.

1935 HUTTON, DAVID, B.A., Harthill School, Lanarkshire; 35, Wood Street, Coatbridge, Lanarkshire, Scotland.

1935 HYDEN, Miss CONSTANCE, B.Sc., County School for Girls, Wrexham; Denton, Rossett, Nr. Wrexham, Denbighshire.

1936 IMESON, KENNETH ROBERT, M.A., A.R.Ae.S.I., Boys' Grammar School, Watford; 20, The Gardens, Watford, Herts.

1926 INCE, EDWARD LINDSAY, M.A., D.Sc., F.R.S.E., F.R.A.S., Department of Technical Mathematics, University of Edinburgh; Mathematical Institute, 16, Chambers Street, Edinburgh.

1919 INCE, Miss GEORGINA MAUDE, B.A., West Norfolk and King's Lynn High School; Padstowe, King George V Avenue, King's Lynn, Norfolk.

1919 INCE, RALPH EDWARD, M.A., 20, Carlton Road, Romford, Essex.

1929 INGLIS, ALEXANDER, M.Sc., Ph.D., Bell-Baxter School, Cupar, Fife; Morig, Newport, Fife, Scotland.

1919 †INMAN, STEVEN, B.Sc., County School, Isleworth; 125, Jersey Road, Osterley Park, Middlesex.

1937 INSLEY, Miss GERTRUDE MARY, B.A., Dulwich High School; 6, Elm Road, Beckenham, Kent.

1937 IRONMONGER, EDWARD ERNEST, B.Sc., 62, Perth Road, Plaistow, London, E.13.

1929 IRONSIDE, Miss MARGARET ADELAIDE, M.A., Putney County Secondary School; 6, Dryburgh Road, Putney, London, S.W.15.

1926 IVES, Miss ETHEL MAY, B.A., The High School for Girls, Kettering, Northants; 201, Abington Avenue, Northampton.

1936 JACKES, WILLIAM EDGAR, St. Dunstan's, West Worthing, Sussex.

1927 JACKSON, Captain ALEXANDER, M.A., King Edward School, Birmingham; 355, Pershore Road, Edgbaston, Birmingham, 5.

1924 JACKSON, FREDERICK THOMAS, M.A., Oundle School; 16, Glapthorn Road, Oundle, Peterborough, Northants.

1920 JACKSON, GORDON BALMBRA, M.A., M.Ed., Head Master of Ashton-under-Lyne Grammar School; Cawthorne, 71, Thornfield Avenue, Ashton-under-Lyne, Lancs.

1921 JACKSON THOMAS HODGES, B.A., M.Ed., County Secondary School, Runcorn, Cheshire; Wyngarth, Allerton Drive, Liverpool, 18.

1925 JACKSON, WILLIAM HARTAS, M.A., H.M. Inspector of Technical Schools; Board of Education, Queen Anne's Chambers, 41, Tothill Street, Westminster, S.W.1.

1932 JAMESON, Miss ANNE, B.Sc., Fulham County Secondary School; 88, Redcliffe Gardens, London, S.W.10.

1910 †JAMESON, Miss EDITH LETTY, c/o Standard Bank of South Africa, Clement's Lane, London, E.C.4.

1934 JAMESON, FRANCIS NOEL, B.Sc., Park Modern School, Barking; 94, South Park Terrace, Ilford, Essex.

1930 JANES, Miss WINIFRED GLADYS, B.A., Raine's Foundation School for Girls, Stepney; 98, Ealing Road, Wembley, Middlesex.

1930 JARVIS, Miss DORIS MARION, B.Sc., Richmond County School for Girls, Surrey; 33, Oakfield Road, West Croydon, Surrey.

1923 JEFFERY, GEORGE BARKER, M.A., D.Sc., F.R.S., Fellow of University College, and Astor Professor of Mathematics in the University of London, King's College; Balnagall, Potter Street, Pinner, Middlesex.

1935 JENKINS, STANLEY LEWIS, B.Sc., Penarth County School; 76, Redlands Road, Penarth, Nr. Cardiff, Glam.

1921 JEVONS, Miss VICTORIA MARY, B.Sc., Ackworth School; Ackworth House, Ackworth, Yorks.

1933 JEX-BLAKE, Miss FRANCES LUBBOCK, B.A., Wakefield Girls' High School; The Old Hall, Reedham, Norfolk.

1935 JOCKEL, CHARLES L. M., M.A., Secondary School, Turriff; Gladstone Terrace, Turriff, Aberdeenshire.

1926 JOHNSON, BERNARD, M.A., Grammar School for Boys, Barrow-in-Furness.

1933 JOHNSON, CHARLES F., Jr., A B., A.M., Luzerne County Industrial School, Kis-Lyn, Pennsylvania, U.S.A.

1935 JOHNSON. ERIC, M.A., Royal Grammar School, Newcastle-upon-Tyne, 2.

1917 JOHNSON, GEORGE, F.R.Econ.S., F.C.R.A., F.C.I.S., Melcombe, 97, Leighton Avenue, Leigh-on-Sea, Essex.

1908 JOHNSTON, JOHN ALEXANDER, M.A., formerly of Haileybury College; Fairview, Hunstanton, Norfolk.

1934 JOHNSTON, SIDNEY, A.C.A., 63, Brown Street, Manchester, 2.

1937 JOLLIFFE, ALFRED CYRIL, B.Sc., Brampton Junior Mixed School, School Board Lane, Chesterfield, Derbyshire.

1917 †JONES, DAVID LLEWELYN, B.Sc., A.C.P., 132, Holton Road, Barry, Glam.

1925 JONES, EDWARD W., B.A., Norfolk Road, Coorparoo, Brisbane, Queensland, Australia.

1935 JONES, Miss ETHEL EMILY, M.Sc., Hove County School for Girls; 193, Chevening Road, Kilburn, London, N.W.6.

1932 JONES, Miss EVELYN MAY, M.A., Durham Girls' County School, Durham City.

1925 JONES, FRANK LEWIS KERRISON, M.A., The Holt School, Liverpool; 46, Woolacombe Road, Childwall, Liverpool, 16.

1920 JONES, Miss GWLADYS, B.A., Girls' County School, Aberdare, Glam.

1932 JONES, HENRY NORMAN, M.A., The Grammar School, Swanage, Dorset.

1920 †JONES, Captain IVAN FITZROY HIPPISLEY, B.A., King's College, Taunton; Kingston Cottage, Kingston, Nr. Taunton, Somerset.

1937 JONES, JONATHAN, B.Sc., Boys' Secondary School, Wrexham; Bryn Villa, 9, Little Acton Drive, Wrexham, Denbighshire.

1921 †JONES, JOSEPH, B.Sc., County Intermediate School, Towyn; 10, Penslade Terrace, Fishguard, Pembrokeshire.

1923 JONES, LATHAM ALAN WEBBER, B.Sc., Berkhamsted School; Ronhead, 10, Montague Road, Berkhamsted, Herts.

1937 JONES, LESLIE EDWIN, M.Sc., Aldenham School, Elstree, Herts.

1936 JONES, Miss OLWEN MARY, B.Sc., M.Sc., Secondary School for Girls, Caerphilly, Glam; 10, Heath Park Avenue, Cardiff, Glam.

1937 JONES, ROBERT, B.A., Taunton's School, Southampton.

1937 JONES, ROBERT WILLIAM, B.Sc., Queen Elizabeth Grammar School, Penrith, Cumberland.

1935 JONES, Miss RUTH MARION, B.Sc., Felixstowe College for Girls, Felixstowe, Suffolk.

1933 JONES, VERNON HEDLEY, M.A., The Grammar School, Wolverhampton.

1928 JOSELAND, HENRY LINCOLN, M.A., B.A., Wendover, Victoria Road, Wilmslow, Manchester.

1929 JOSLIN, Miss HILDA HETTY, B.A., Stoke Damerel Secondary School for Girls, Devonport, Plymouth; 55, Federation Road, Laira, Plymouth, Devon.

1928 JOYNER, CEDRIC BATSON, M.A., H.M.I., Hoopern Lodge, Pennsylvania, Exeter, Devon.

1936 JUCKES, RALPH, M.A., Milner Court, Sturry, Kent.

1911 JURDAK, MANSUR HANNA, M.A., Professor of Mathematics in the American University of Beirut, Beirut, Syria.

1932 KALAUGHER, WILFRID GEORGE, M.A., B.A., B.Sc., Marlborough College, Wilts.

1937 KAPUR, JAI BHAGWANLAL, B.Sc., Rajkumar College, Raipur, C.P., India.

1924 KATZ, JACQUES, B.A., Selhurst Grammar School, The Crescent, Croydon; 25, Clairview Road, Streatham, London, S.W.16.

1934 KAY, FRANK, B.Sc., Darwen Grammar School; 83, Belgrave Road, Darwen, Lancs.

1929 KEARNEY, ROY ALAN MOUNT, B.A., 95, Cromwell Road, Wimbledon, London, S.W.19.

1920 KEEGAN, JOHN, B.Sc., A.R.C.S., County Secondary School, Jarrow; 76, Croft Terrace, Jarrow-on-Tyne, Co. Durham.

1922 KEELING, JOHN, B.A., Hartlebury Grammar School; Wynncote, Hartlebury, Nr. Kidderminster, Worcs.

1934 KELLAWAY, WALTER GEORGE, B.Sc., Colne Grammar School; 150, Skipton Road, Colne, Lancs.

1933 KELLY, VINCENT PETER, M.A., West Ham Grammar School; 232, Northumberland Avenue, Welling, Kent.

1922 KELSO, ROBERT JOHN, M.A., Woodhouse Secondary School, Sheffield; 123, Sandford Grove Road, Nether Edge, Sheffield, Yorks.

1931 KEMP, CHARLES EDWARD, M.A., Headmaster of the Grammar School, Chesterfield, Derbyshire.

1927 KEMPSON, EDWIN GARNETT HONE, M.A., Marlborough College, Wilts.

1935 KENDALL, EDWARD SHERWOOD, M.A., Uppingham School; West Bank, Uppingham, Rutland.

1926 KENNEDY, HOWARD, M.Sc., Queen Elizabeth's Grammar School, Blackburn; Dunelm, 48, Lammack Road, Blackburn, Lancs.

1924 KENWORTHY-BROWNE, BERNARD EVELYN, M.A., Head Master of Wellbury Park Preparatory School; Wellbury Park, Hitchin, Herts.

1923 KERR, RICHARD A., M.A., B.Sc., Head Master of the Boys' Grammar School, Ipswich, Queensland, Australia.

1935 KERSHAW, EDWARD, B.Sc., Bishop Auckland Grammar School; 165, Redworth Road, Shildon, Co. Durham.

1923 KERSHAW, JOSEPH, M.A., Hackney Downs School, London, E.8; The Orchard, Birdham Road, Apuldram, Chichester, West Sussex.

1935 KHARAS, SORAB PHIROZESHAH, B.A., Princess High School for Girls, Bombay; C. Block, Gowalia Tank Buildings, Gowalia Tank Road, Bombay, 7, India.

1933 KIERAN, Rev. FRANCIS PATRICK, M.A., Upholland College, Wigan, Lancs.

1935 KILGOUR, JAMES, M.A., Adams' Grammar School, Newport, Salop; 23, Vineyard Road, Wellington, Salop.

1935 KILLINGLEY, Miss DORIS McDOWELL, M.A., Richmond High School, Yorks; 2, Pottergate, Richmond, Yorks.

1937 KING, Miss DOROTHY LOCKE, B.Sc., The Queen's School, Chester; 33a, Henry Road, West Bridgford, Nottingham.

1931 KING, REGINALD STANLEY, B.Sc., Harrow County School, Gayton Road, Harrow, Middlesex; Savani, Goreland's Lane, Chalfont St. Giles, Bucks.

1923 KING, Miss RUTH HARDY, M.A., Head Mistress of the County High School for Girls, Colchester; Bank House, 60, High Street, Colchester, Essex.

1934 KING, WILLIAM HENRY, B.Sc., A.K.C., Strand School, Elm Park, London, S.W.2; Cartref, Verlin Estate, Bishopsteignton, South Devon.

1935 KINGDON, PURCELL SAMUEL THOMAS, B.Sc., Secondary School, Porth, Glam.; 37, Tyntyla Road, Ystrad Rhondda, Glam.

1934 KIRKWOOD, HUGH R., B.A., Wrekin College, Wellington, Shropshire; Boldrewood, Burghfield Common, Reading, Berks.

1929 KIRSOP, Miss KATHLEEN PEARSON, B.Sc., Rochester Grammar School for Girls; 37, Star Hill, Rochester, Kent.

1936 KNIGHT, ALBERT EDWARD, B.Sc., Brigg Grammar School, Wrawby Road, Brigg, Lincs.

1934 KNIGHT, ARTHUR, M.A., Barnsley Grammar School; The Isis, Allerdale Road, Barnsley, Yorks.

1937 KNIGHT, DONALD, B.A., The Grammar School, Earls Colne, Essex; Ross Common, Healds Road, Dewsbury, Yorks.

1909 †KNIGHT, FRANCIS HOWARD, M.A., Secretary, Friends' Education Council, Friends' House, Euston Road, London, N.W.1.

1936 KNIGHTING, ERNEST, B.Sc., Bolam Street School, Newcastle-upon-Tyne, 6; 28, Mundella Terrace, Newcastle-upon-Tyne, 6.

1932 KOH, ENG KWANG, St. Andrew's School, Singapore, Straits Settlements.

1931 LABEY, JULIUS EDMUND GRUCHY, M.A., Exeter School; Belfield, Lyndhurst Road, Exeter, Devon.

1930 LACE, Miss OLIVE JESSIE, M.A., St. Margaret's School, Bushey, Herts.

1925 LAING, Miss ANNIE SUTHERLAND, M.A., Co-Principal of Prahran College; 166, Williams Road, East Prahran, Victoria, Australia.

1932 †LAKE, Miss DOROTHY, B.A., Eltham Hill School; 1, Montague Avenue, Brockley, London, S.E.4.

1923 LANGDON-DAVIES, HUGH, M.A., The School, Ripon, Yorks; 42, Garden Walk, Cambridge.

1930 †LANGFORD, CHARLES DUDLEY, B.Sc., Ph.D., A.R.C.S., The Sacred Heart R.C. School, Girvan, Ayrshire.

1925 LANGFORD, WALTER JAMES, M.Sc., F.R.A.S., Head Master of the Grammar School, Bideford, N. Devon.

1895 LARMOR, Sir JOSEPH, M.A., D.Sc., LL.D., F.R.S., Hon.Sc.D., Lucasian Professor of Pure Mathematics in the University of Cambridge; Fellow of St. John's College, Cambridge. (President, 1895–1896.)

1933 †LARMOUR, JAMES, M.A., B.Sc., Rugby School; 39, Hillmorton Road, Rugby, Warwickshire.

1929 LARRETT, WALTER DENHAM, M.A., The King's School, Peterborough, Northants.

1935 LAURISTON, Miss JANE, B.A., Westonbirt School, Tetbury, Glos.

1936 LAUWERYS, JOSEPH ALBERT, B.Sc., University of London, Institute of Education, Southampton Row, London, W.C.1.

1929 LAWRENCE, BERNARD EDWIN, M.A., B.Sc., Ph.D., Assistant for Higher Education Committee, Essex Education Committee; Hill Crest, Wood Street, Chelmsford, Essex.

1928 LAX, EDWARD, M.A., B.A., Dulwich College, London, S.E.21.

1936 LEACH, Miss ANNIE, B.Sc., Penrhos College, Colwyn Bay, North Wales; 2, School Street, Bingley, Yorks.

1930 LEACH, Miss EVA FRANCES, B.Sc., County School for Girls, Peterborough; 344, Fulbridge Road, Peterborough, Northants.

1934 LEADBEATER, JOHN G., B.A., Toowoomba Grammar School, Toowoomba, Queensland, Australia.

1922 LEAKE, Miss ANNIE ELIZABETH, B.A., Holly Lodge High School, Queen's Drive, Liverpool, 13; 5, Sandforth Road, West Derby, Liverpool.

1931 LEAR, Miss MARY (Math. Trip.), The Girls' Collegiate School, Maritzburg, Natal, South Africa.

1934 LEATHARD, JOSEPH WILLIAM, M.Sc., Washington County Secondary School, Co. Durham; 7, Dunsany Terrace, Pelton Fell, Co. Durham.

1935 LECOMBER, HERBERT, M.A., King's College School, Wimbledon; 24, St. George's Square, London, S.W.1.

1908 LEE, Miss FLORENCE KATE, M.A., 30, Blenheim Crescent, South Croydon, Surrey.

1937 LEESE, Miss STEPHANIE MARY, B.Sc., North London Collegiate School; 24, Rollscourt Avenue, Herne Hill, London, S.E.24.

1936 LEGG, JAMES WILLIAM, B.Sc., Fletton Secondary School, Hunts.; 112, London Road, Peterborough.

1937 LEGON, Miss CONSTANCE TERESA, B.Sc., Hornsey High School; 55, Riverway, Palmers Green, London, N.13.

1928 LEHFELDT, Miss WINIFRED MARY, M.A., St. Paul's Girls' School, London; 35, King's Road, Richmond, Surrey.

1926 LEIGH, Miss CONSTANCE MARY, B.A., Kidderminster High School; 1, Comberton Farm, Kidderminster, Worcs.

1933 LEIGHTON, Miss LENA, B.Sc., Birkenhead High School, Devonshire Place, Birkenhead, Cheshire.

1904 †LENFESTEY, STANLEY DE JERSEY, M.A., Inspector of Schools, Southern Rhodesia; Arboretum, Gwelo, Southern Rhodesia, South Africa.

1937 LEONARD, Miss DORIS MAY, B.Sc., Coborn School for Girls; 29, Nesta Road, Woodford Green, Essex.

1928 LESTER, GEORGE HERMAN, M.A., Bristol Grammar School; 6, Park Drive, Bradford, Yorks.

1931 LESTER, ROLAND EDWARD, M.A., Wilson's, The College, Brighton, Sussex.

1912 LEWIS, EDWARD PHILIP, M.A., Clifton College; 41, Canynge Square, Clifton, Bristol, 8.

1930 LEWIS, Miss FLORENCE MAY, B.A., Mitcham County School for Girls; 9, High Street, Hitchin, Herts.

1910 LEWIS, JOHN, B.Sc., Northgate School for Boys, Ipswich; 53, Bristol Road, Ipswich, Suffolk.

1913 LEWIS, JOHN WILLIAM, B.Sc., H.M. Inspector of Schools; Court Crescent, Bassaleg, Mon.

1930 LEWIS, Miss O. M., Intermediate School for Girls, Treforest, Pontypridd, Glam.

1935 LEWIS, Miss SARAH, B.A., County School, Llandilo; Lasael, Llandilo, Carmarthenshire, South Wales.

1923 LEWIS, STANLEY THOMAS, B.A., A.K.C., Bromley County School for Boys; 38, Coniston Road, Bromley, Kent.

1908 LEWIS, WILLIAM ALDERSEY, M.A., 32, Lee Park, Blackheath, London, S.E.3.

1934 LEWIS, WILLIAM HAROLD, Strathallan School, Forgandenny, Perthshire; 162, Torridon Road, Catford, London, S.E.6.

1925 LEWSLEY, BERNARD JOHN, B.Sc., 8, St. Anne's Road, Coventry, Warwickshire.

1920 †LIDSTONE, GEORGE JAMES, LL.D., F.R.S.E., F.I.A., F.F.A., Hermiston House, Hermiston, Currie, Midlothian, Scotland.

1935 LIGHT, KENNETH GEORGE, B.Sc., The North Manchester Municipal High School for Boys, Chain Bar, Manchester.

1922 LIGUORI, Rev. Brother, B.A., St. Joseph's College, Hunter's Hill, Sydney, New South Wales, Australia.

1920 LINES, LESLIE, M.A., B.Sc., County Secondary School, Colwyn Bay; The Hawthorns, Llanelian, Colwyn Bay, North Wales.

1921 LINFIELD, Miss ELLEN, B.A., Central Newcastle High School, Eskdale Terrace, Newcastle-upon-Tyne.

1932 LINFOOT, Mrs. JOYCE, M.A., 13, Alexandra Road, Clifton, Bristol.

1924 LISLE, FREDERICK BYARD, M.A., Grammar School, Kingsbridge, South Devon.

1930 LISTER, Miss FLORA, Lancaster Girls' Grammar School; 3, Queen Square, Lancaster.

1912 LISTER, JOHN, A.R.C.Sc., Omega, Lowes Lane, Gawsworth, Macclesfield, Cheshire.

1920 LISTER, SAMUEL, M.Sc., Head Master of the County School for Boys, Gravesend; Macknade, 124, Darnley Road, Gravesend, Kent.

1936 LITTLE, Miss JOY, B.A., Marchwood, 5, Granville Road, Bournemouth.

1930 LIVENS, GEORGE HENRY, M.A., Professor of Mathematics, University College, Cardiff, Glam.

1936 LLOYD, DONALD CHARLES, B.A., Merchant Taylors' School; 6, Southdown Lawn Road, Highgate, London, N.6.

1925 LLOYD, Miss DOROTHY MANDEVILLE, B.A., Stockport High School, Stockport, Cheshire.

1933 LLOYD, Miss ELIZABETH (Math. Trip.), Skipton High School; 136, Waterloo Road, Birkdale, Lancs.

1920 LLOYD, Miss EVELYN, Westfield, Brough, Yorks.

1932 LLOYD, RHYS GERRAN, M.A., B.Sc., Bembridge School, Isle of Wight.

1922 LOB, HYMAN, M.A., Manchester Grammar School, Fallowfield, Manchester.

1934 †LOCKE, CYRIL STANLEY, M.A., Collyer's School, Horsham, Sussex.

1909 LOCKE, GEORGE THOMAS, M.A., Head Master of Stand Grammar School, Whitefield; Spring Bank, Whitefield, Nr. Manchester.

1925 LOCKWOOD, EDWARD HARRINGTON, M.A., The Bury, Felsted School, Essex.

1888 LODGE, ALFRED, M.A., formerly Professor of Mathematics in the Royal Indian Engineering College; 336, Banbury Road, Oxford. (Treasurer, 1891-6; President, 1897-1898.)

1935 LOFTHOUSE, Miss FRANCES WINIFRED, B.Sc., Queen Mary School, Lytham, Lancs.

1896 LONEY, SIDNEY LUXTON, M.A., B.A., Parkside, 172, Kew Road, Richmond, Surrey.

1926 LORD, Miss ELLEN ELIZABETH, M.A., Bromley High School for Girls; Rawdon, Hutton Mount, Brentwood, Essex.

1918 LORD, Miss PHEBE GOODGER, B.A., King's High School for Girls, Warwick; St. Mark's Vicarage, Leamington Spa, Warwickshire.

1936 LOVEDAY, ROBERT, B.Sc., M.Sc., Ecclesfield Grammar School; The Nucleus, Park View Road, Chapeltown, Nr. Sheffield.

1931 LOVERIDGE, NORMAN JOHN, B.A., The King's School, Gloucester; 17, Waverley Road, Gloucester.

1936 LOWERY, HARRY, M.Ed., Ph.D., D.Sc., F.C.P., F.Inst.P., Principal, North Western Polytechnic, London, N.W.5.

1922 LOWRY, HUGH VERNON, M.A., Head of Mathematical Department, Woolwich Polytechnic; 35, North Park, Eltham, London, S.E.9.

1935 LOWTHER, Miss PHYLLIS, B.A., The Duchess's School, Alnwick; 16, Bondgate Without, Alnwick, Northumberland.

1931 LUCIA, BERTRAM CHARLES, B.Sc., Bootham School, York.

1911 LUCY, ALBERT WILLIAM, M.A., 8, Robin Hood Lane, Hall Green, Birmingham.

1903 LYNCH, Miss MURIEL AMAY ROCHE, M.A., 33, Elsham Road, West Kensington, London, W.14.

1934 LYNESS, ROBERT CRANSTON, B.A., Repton School, Derby.

1910 LYON, MALCOLM SINCLAIR, B.Sc., Merrywood Secondary School, Bristol, 4; 13, Rokely Avenue, Redland, Bristol.

1931 MABBOTT, HERBERT ARTHUR, B.Sc., Enfield Grammar School; 41, Abbey Road, Enfield, Middlesex.

1936 McCARTHY, CONWAY JOSEPH, B.Sc., 21, Calliope Road, Auckland, N.1, New Zealand.

1933 McCARTHY, JAMES PATRICK, M.A., Lecturer in Mathematics in the University of Queensland, Brisbane, Queensland, Australia.

1935 †McCONNELL, GEORGE RICHARDSON, M.A., Harrow School, Harrow-on-the-Hill, Middlesex.

1924 McCORMICK, Miss EDITH MAUD, B.Sc., Liverpool Institute High School for Girls; 22, Salisbury Road, Wavertree, Liverpool.

1936 McCREA, WILLIAM HUNTER, M.A., B.Sc., Ph.D., F.R.S.E., Professor of Mathematics in the Queen's University of Belfast; The Queen's University, Belfast, Northern Ireland.

1927 McCULLOCH, Miss MINNIE, B.A., St. Hilda's School, Southport, Queensland, Australia.

1936 MACDONALD, ALEXANDER, M.A., Royal Belfast Academical Institution; 31, St. Ives Gardens, Stranmillis, Belfast.

1927 MACDONALD, RANALD, M.A., M.Sc., B.Sc., County Secondary School, Long Eaton, Derbyshire; Moorfield, Breaston, Derby.

1932 MACDONALD, THOMAS JOHN, B.A., B.Sc., Acklam Hall Secondary School, Middlesbrough, Yorks.

1926 MACDONALD, WILLIAM KEAN, B.Sc., County Secondary School, New Mills, Derbyshire; Greenways, Stockport Road, Marple, Nr. Stockport.

1935 McGOVERN, PATRICK B., B.A., Teachers' Training College, 124, Fortescue Street, Spring Hill, Brisbane, Queensland, Australia.

1935 MACGREGOR, Miss LILIAN MARY, LL.A., Saltburn High School for Girls; 7, Gill Street, Saltburn-by-the-Sea, Yorks.

1929 McINTOSH, Miss KATHLEEN WINIFRED, M.A., St. Paul's Girls' School, London; 85, Arran Road, Catford, London, S.E.6.

1933 McINTYRE, Miss JESSIE, B.A., The College, Pontypool, Mon.

1932 McKELVIE, Miss MARY, M.A., County Girls' High School, Cambridge; 32, Blinco Grove, Cambridge.

1937 MACKENZIE, ALAN FAIRBAIRN, B.Sc., 71, St. Leonard's Road, Exeter.

1924 MACKENZIE, Miss KATHLEEN IVY, B.A., The Girls' School, Newbury; 13, Catherine Road, Newbury, Berks.

1935 MACKINNON, PHILIP VALENTINE, M.A., Eton College, Windsor, Berks.

1936 MACKINTOSH, Miss CATHERINE FLORENCE MACDONALD, B.Sc., Kensington High School; 103, The Chine, Grange Park, London, N.21.

1919 McLACHLAN, Miss HANNAH, B.A., The County High School for Girls, Colworth Road, Leytonstone, E.11; 46, Belmont Park, London, S.E.13.

1935 McLEAN, EDWARD, M.Sc., Whitcliffe Mount Grammar School, Cleckheaton; Victoria Villa, Cleckheaton, Yorks.

1931 McLEOD, DAVID, M.A., B.Sc., Hutt Valley High School, Lower Hutt, N.Z.; Lockett Street, Lower Hutt, New Zealand.

1923 McLINTOCK, WILLIAM GILMOUR, M.A., B.Sc., North Kelvinside Secondary School, Glasgow; 4, Striven Gardens, Glasgow, N.W.

1930 McMICHAEL, JOHN FISHER, O.B.E., B.A., St. Edward's School, Oxford.

1926 MACPHIE, DONALD, M.A., B.Sc., The Academy, Rutherglen, Lanarkshire; 35, Balvicar Street, Queen's Park, Glasgow, S.2.

1934 MACRO, WILLIAM BRINDLEY, M.A., Royal Grammar School, Newcastle-upon-Tyne; 11, Roseworth Terrace, Gosforth, Newcastle-upon-Tyne, 3.

1910 McWHAN, JOHN, M.A., Ph.D., F.R.S.E., University of Glasgow; 37, Airthrey Avenue, Jordanhill, Glasgow, W.4.

1936 MADDEN, FRANK COX, M.Sc. (Private Tutor), 233, Staines Road, Twickenham, Middlesex.

1937 MAFFEY, GEOFFREY LOUIS, B.A., 11, Balfour Road, Parnell, Auckland, C.4, New Zealand.

1935 MAHER, ALFRED DENIS, B.Sc., Ilminster Grammar School; 21, New Road, Ilminster, Somerset.

1914 MAHONEY, J. O., M.Sc., B.E., Director, Public Evening Schools, Dallas; 6120, Junius Street, Dallas, Texas, U.S.A.

1920 MAKINSON, Miss NORA, B.Sc., Belle Vue Girls' Secondary School, Manningham Lane, Bradford, Yorks.

1937 MALLETT, Miss FRANCES EMMA, B.Sc., Headington School, Oxford; Davenport House, Headington Hill, Oxford.

1926 MALLINSON, Captain HENRY, B.Sc., Dame Allan's Boys' School, Newcastle-on-Tyne, 1.

1924 MALLISON, HAROLD VINCENT, M.A., B.Sc., Lecturer in Mathematics, University College, Exeter, Devon.

1931 MALLORY, VIRGIL SAMPSON, A.B., A.M., Associate Professor of Mathematics, State Teachers' College, Montclair, New Jersey, U.S.A.

1920 MAMLOCK, PHILIP, B.A., William Ellis School, Gospel Oak, N.W.5; 38, Morton Way, Southgate, London, N.14.

1933 MANDER, Miss FLORENCE, B.A., Totnes County School for Girls; Weirnook, Totnes, Devon.

1935 MANISTY, JOHN COLLINGWOOD, B.A., Thornton, Christ's Hospital, Horsham, Sussex.

1930 MANNING, WILLIAM, M.A., Maidstone Grammar School; Karaburun, Pear Tree Lane, Loose, Kent.

1935 MANSON, CHARLES WILLIAM MACKAY, M.A., High School, North Berwick; 28, Glenburn Road, North Berwick, East Lothian, Scotland.

1935 MAPLES, BRYAN ASHLEY, M.A., Marlborough College, Wilts.

1935 MARBERGER, CLIFFORD, Denver, Pennsylvania, U.S.A.

1926 MARKS, HAROLD FREDERICK, B.Sc., King's School, Grantham; Exon, Signal Road, Grantham, Lincs.

1932 MARLOW, Rev. Brother C. C., B.A., St. Kevin's College, Orrong Road, Toorak, Melbourne, S E 2, Victoria, Australia.

1937 MARRIOTT, JOHN WILLIAM FITZGERALD, M.A., Makerere College, Kampala, Uganda, British East Africa.

1912 MARSDEN, HUGH KENYON, M.A., Eton College, Windsor, Berks.

1929 MARSDEN, THOMAS, M.A., B.Sc., Cambridge County School for Boys; Fixby, Perne Road, Cambridge.

1935 MARSH, ALBERT HENRY WILLIAM, B.Sc., Yardley Secondary School; 60, Highfield Road, Hall Green, Birmingham.

1927 MARSH, REGINALD JOHN, M.A., The Herbert Strutt School, Belper; Wyedene, Flaxholme, Duffield, Nr. Derby.

1911 †MARSHALL, Miss FREDERICA L., B.A., Varndean School for Girls, Brighton; 285, Ditchling Road, Brighton, Sussex.

1936 MARSHALL, JOHN BROWN, M.A., B.Sc., 10, Corstorphine Road, Edinburgh, 12.

1928 MARSHALL, RICHARD LUCAS, M.A., Muncaster School, Ashford, Middlesex.

1927 MARTIN, ANDREW, M.A., B.Sc., Cumnock Academy, Ayrshire; 13, Seafield Drive, Ayr, Scotland.

1925 MARTIN, EDWARD STANLEY, B.Sc., Ph.D., Northern Polytechnic, Holloway, London, N.7; 8, Briton Close, Sanderstead, Surrey.

1932 MARTIN, ERNEST WILLIAM HENRY, B.Sc., Rastrick Grammar School, Brighouse; 5, Close Lea, Rastrick, Brighouse, Yorks.

1915 MARTIN, Miss HILDA MARY, B.Sc., Loughton High School for Girls; 25, Grange Court, Loughton, Essex.

1930 MARTINDALE, ARNOLD, B.Sc., A. J. Dawson Secondary School, Wingate; Wayside, Durham Road, Wingate, Co. Durham.

1936 MARTYN, WALTER CHARLES, B.Sc., Great Duryard House, Cowley Road, Exeter.

1912 MARTYN, W. J., M.A., Otago Boys' High School, Dunedin, New Zealand.

1910 MARZIALS, FRANÇOIS MAURICE, M.A., 15, Ashgrove, Musselburgh, Midlothian, Scotland.

1936 MASKELL, FREDERICK GEORGE BERRY, B.A., St. John's College School, Winnipeg, Canada.

1936 MASON, EATON DICKENS, B.A., Royal Masonic (Senior) School, Bushey, Herts; 81, Uphill Road, Mill Hill, London, N.W.7.

1924 MATHEWS, Miss ALMA, M.A., The Godolphin and Latymer School for Girls, Hammersmith, W.6; Kenilworth, 23, Blenheim Road, St. Albans, Herts.

1933 MATHEWS, Miss IRENE MAUD (Math. Trip.), Thoresby High School, Leeds; Flat 3, Allerton Lodge, Falkland Mount, Leeds, 7.

1937 MAW, WILLIAM NAWTON, B.A., C.I.E., Colnville, The Island, Longford, Middlesex.

1936 MAXWELL, EDWIN ARTHUR, M.A., Ph.D., Queens' College, Cambridge; 71, De Freville Avenue, Cambridge.

1933 MAY, ALBERT JAMES GOODING, B.A., Minehead County School; Shaugh Prior, West Park, The Parks, Minehead, Somerset.

1914 †MAYNE, ARTHUR BRINLEY, M.A., Head Master of the Cambridge and County High School for Boys; 213, Hills Road, Cambridge.

1927 MAYNE, WILLIAM LAWRENCE, M.A., B.A., King George V. School, Southport; 27, Curzon Road, Southport, Lancs.

1936 MAYOR, FRED, M.A., Head Master of the Grammar School, Hull, Yorks.

1935 MEACOCK, GEORGE HENRY, B.Sc., Harwich County High School, Dovercourt, Essex.

1928 MEAD, LEONARD FREDDIE WILLIAM, M.A., University College School, Hampstead; 242, Gunnersbury Avenue, London, W.3.

1918 MEAD, Miss MARGARET J., B.Sc., Tiffin Girls' School, Kingston-on-Thames; 6, Holland Villas Road, London, W.14.

1919 MEADE-KING, OLIVER, M.A., Malvern College; 4, College Grounds, Malvern, Worcestershire.

1925 MEARS, HENRY JOHN, B.Sc., Queen Elizabeth's Grammar School, Ashbourne; Bushmead, Windmill Lane, Ashbourne, Derbyshire.

1937 MEETHAM, Miss MILDRED JOAN, B.Sc., Chesterfield Girls' High School; 11, Huntley Road, Sheffield, 11.

1920 MEGSON, MANFRED, M.A., Rugby School; Tudor House, Rugby, Warwickshire.

1926 MEIXNER, FREDERICK, M.A., St. Paul's High School, Edgbaston; 2, Thornby Avenue, Solihull, Birmingham.

1918 †MELDRUM, HENRY JOHN, B.A., B.Sc., Senior Lecturer in Mathematics, The Teachers' College, University Grounds, New Town, Sydney, New South Wales, Australia.

1920 MELLOR, Miss DOROTHY LEAH, B.A., Haberdashers' Aske's Girls' School, Hatcham; 72, Shrewsbury Lane, Shooter's Hill, London, S.E.18.

1911 MERCER, JOHN WILLIAM, M.A., formerly Head of Military and Engineering Side, Cheltenham College; Sarnway, Charlton Park Gate, Cheltenham, Glos.

1936 MERMAGEN, PATRICK HASSELL FREDERICK, B.A., Loretto School, Musselburgh; 4, Hollybush Gardens, Musselburgh, Midlothian, Scotland.

1935 MERRILES, ALEXANDER JOHNSON, M.A., B.Sc., George Watson's Ladies' College; 13, Strathfillan Road, Edinburgh.

1930 MERRIMAN, Miss DORIS ELIZABETH, M.Sc., B.Com., Ealing County School for Girls; The Nest, Norwood Green, Middlesex.

1924 †METZLER, Professor WILLIAM HENRY, Ph.D., D.Sc., F.R.S.E., F.R.S.C., 5003 So, Salina Street, Syracuse, New York, U.S.A.

1925 MICHELL, Professor JOHN HENRY, M.A., F.R.S., 52, Prospect Hill Road, Camberwell, Victoria, Australia.

1935 MIDDLETON, DOUGLAS HENRY, B.Sc., Taunton School; 2, Turner Road, Taunton, Somerset.

1937 MIDDLETON, THOMAS WILLIAM BLACKBURN, B.A., Marlborough College, Wilts.

1932 MIDGLEY, ARTHUR, B.A., County Secondary School, West Bridgford, Nottingham.

1926 MIELZINER, Miss DORIS JULIET, M.A., The Queen Mary High School, Liverpool; Ladies' Residential Club, 21, Gambier Terrace, Liverpool, 1.

1926 MILES, FREDERICK FISHER, M.A., Lecturer in Mathematics, Victoria University College, Wellington, New Zealand.

1926 MILES, LEONARD, B.Sc., Chipping Norton County School; Woodville, Rock Hill, Chipping Norton, Oxon.

1936 MILFORD, MICHAEL, M.A., Repton School; 2, The Pastures, Repton, Derby.

1931 MILLER, HERBERT HENRY FRANCIS, M.A., Brentwood School, Essex; 31, Kempshott Road, Streatham Common, London, S.W.16.

1912 MILLER, JOHN, M.A., D.Sc., F.R.S.E., formerly Professor of Mathematics in the Royal Technical College, Glasgow; 212, Wilton Street, Glasgow, N.W

1913 †MILNE, JOHN, M.A., Training Centre for Teachers, Aberdeen; 7, St. Swithin Street, Aberdeen.

1884 †MILNE, Rev. JOHN JAMES, M.A., Glengarry, Lee-on-the-Solent, Hants. (Hon. Treasurer, 1897-1899; Hon. Secretary, 1896.)

1902 †MILNE, ROBERT MOIR, M.A., Radegund, Pennington, Lymington, Hants.

1909 MILNE, WILLIAM PROCTOR, M.A., D.Sc., Professor of Mathematics in the University of Leeds; 16, Monkbridge Road, Headingley, Leeds, Yorks.

1935 †MILNE-THOMSON, LOUIS MELVILLE, M.A., F.R.S.E., Professor of Mathematics, Royal Naval College, Greenwich, London, S.E.10.

1920 MILNES, JOHN, B.Sc., Huddersfield Technical College; 75, Birkby Lodge Road, Huddersfield, Yorks.

1935 MINOIS, SERGE, Agrégé de l'Université Professeur de Mathématiques au Lycée de Garçons de Brest; 7, Rue Candelot Bourg-la-Reine, Seine, France.

1936 MITCHELL, CHARLES BROWNLOW, M.A., Headmaster, Edgeborough, Guildford, Surrey

1923 MITCHELL, Miss DOROTHY DUTTON (Math. Trip.), 2, Mortimer Crescent, Kilburn, London, N.W.6.

1925 MITCHELL, Miss IRENE LAURA, B.Sc., Christ's Hospital, Hertford; 80, Fore Street, Hertford.

1924 MONTAGNON, ARTHUR, M.A., The Grammar School, Leeds, Yorks.; 268, Broadway, Horsforth, Leeds.

1933 MONTEFIORE-CASTLE, DEREK LEOPOLD, A.C.P., F.R.Met.S., The Hall, Crossfield Road, Hampstead, N.W 3.

1920 MOOR, JOHN, M.C., M.A., B.Sc., Head Master of Henry Smith School, Hartlepool; 14, Cliff Terrace, Hartlepool, Co. Durham.

1930 MOORE, HARRY NEWNHAM REED, M.A., B.Sc., Head Master, Sandown County Secondary School, Isle of Wight; St. Christopher, Sandown, Isle of Wight.

1935 MOORE, ROGER DAVY LANIFI, M.A., Leighton Park School, Reading; Grove House, Leighton Park, Reading, Berks.

1930 MOORHOUSE, Miss MARY ALICE, M.Sc., Ruabon County Secondary School for Girls; Crabtree House, Wrexham Road, Rhostyllen, Nr. Wrexham, North Wales.

1917 MORGAN, Miss ELLEN MARGARET, B.A., Municipal Secondary School for Girls, Cyfarthfa, Merthyr Tydfil; 1, Dane Terrace, Merthyr Tydfil, Glam.

1925 MORGAN, Miss ELSIE MAUD, Intermediate School for Girls, Treforest, Glam.; 11, Common Road, Pontypridd, Glam.

1931 MORGAN, Miss FLORENCE E. M., B.Sc., Pontypridd Girls' Intermediate School; 24, Gellinastad Road, Pontypridd, Glam.

1935 MORGAN, JOHN BUTLER, B.A., Hereford Cathedral School, Hereford.

1937 MORGAN, Miss MILDRED EDNA MARY, B.Sc., Pontypool County School for Girls; 334, Caerphilly Road, Whitchurch, Cardiff, Glam.

1934 MORGANS, JONATHAN GREY, M.A., Head Master of Swansea Grammar School; Grammar School House, Swansea, Glam.

1935 MORLEY, Miss GWYNETH, B.A., Holly Lodge High School, Smethwick; 14, Buttery Road, Smethwick, Staffs.

1929 MORLEY, PERCEVAL, B.Sc., The Grammar School, Wolsingham; Riversmead, Wolsingham, Co. Durham.

1933 MORNARD, ALFRED JOHN, B.A., Loretto School, Musselburgh, Midlothian, Scotland.

1930 MORRIS, Miss ISOBEL, B.Sc., Abbeydale Secondary School, Millhouses, Sheffield; 206, Abbey Lane, Sheffield, 8, Yorks.

1937 MORRIS, Miss MARIAN, B.Sc., Heathfield High School; Heathfield, College Road, Harrow, Middlesex.

1922 MORRIS, Miss REBECCA EMILY, B.A., Principal of Dinorben High School, Wallington, Surrey; 6, Lawrence Grove, Henleaze, Bristol.

1935 †MORRIS, ROBERT WALTER, B.A., Cheltenham College; Boyne House, Cheltenham, Glos.

1935 MORRIS, THOMAS DAVID, B.A., Charterhouse, Godalming, Surrey.

1935 MORRIS, WILLIAM DAVIES, B.Sc., Barmouth County School; Bryn Teg, Barmouth, Merioneth, North Wales.

1937 MORTON, ALBERT, B.Sc., St. George Secondary School, Bristol; 50, Westerleigh Road, Downend, Bristol.

1929 MORTON, Sister DOROTHEA, C.H.F., B.Sc., Head Mistress of the School of the Holy Family; 79, West Cromwell Road, London, S.W.5.

1927 MOSLEY, Miss EDITH, (Math. Trip.), Blackburn High School for Girls; 2, Ravenswing Avenue, Blackburn, Lancs.

1935 MOSES, STANLEY, B.Sc., John Bright County School, Llandudno; Brookhurst, Howard Road, Llandudno, Caernarvonshire.

1935 MOSS, SAMUEL HYAM, B.Sc., 481, New Cross Road, London, S.E.14.

1933 MOXOM, Captain REGINALD JOHN, B.Sc., Hertford Grammar School; Highlands, Queens Road, Hertford.

1895 MUIRHEAD, ROBERT FRANKLIN, M.A., B.A., D.Sc., Principal of Glasgow Tutorial College; 8, Park Avenue, Glasgow, C.3.

1927 †MULHALL, JAIME E., Retired Officer of the Argentine Navy; Calle Rivadavia 835. Buenos Aires, Argentine Republic.

1931 MUNRO, NORMAN, M.A., B.Sc., County High School, Ilford; 3, Eastern Road, Romford, Essex.

1935 MUNTON, ERIC, M.A., Farnham Grammar School; St. Margaret's, Firgrove Hill, Farnham, Surrey.

1928 MURRAY, Miss DOROTHY EILEEN GARNER, B.Sc., Perse Girls' School, Cambridge.

1933 MURRAY, Miss HELEN CHRISTINA, M.A., Aylesbury Grammar School; Cottymead, Wendover Road, Aylesbury, Bucks.

1924 MURRAY-RUST, THOMAS MORAY, M.A., Westminster School; The White Cottage, Gilwell Lane, Chingford, Essex.

1912 MUSGRAVE, JOHN KIDSON DARBY, M.C., M.A., Acton County School; 21, Loveday Road, Ealing, London, W.13.

1920 NAISH, Miss EDITH MARY, B.A., King's High School for Girls, Warwick; St. Mark's Vicarage, Leamington Spa, Warwickshire.

1931 NARLIKAR, VISHNU VASUDEO, B.A., Professor of Mathematics in the Benares Hindu University, Benares, India.

1928 NAYLOR, VERNON, M.Sc., H.M. Dockyard School, Devonport; Boundary House, Ham Lane, Pennycross, Plymouth, Devon.

1903 NEALE, THOMAS, M.A., Glendoon, College Road, Bromsgrove, Worcs.

1914 NEDHAM, Miss MAUD TEMPLEMAN, B.Sc., Head Mistress of The Queen's School, Chester.

1935 NEEDHAM, JOHN STAFFORD, B.Sc., Knox Grammar School, Wahroonga, New South Wales; 79, Eastern Road, Turramurra, New South Wales, Australia.

1935 NEILL, Miss MARGARET MARY, B.A., Sheffield High School; 6, Dransfield Road, Sheffield, 10.

1936 NELKON, MICHAEL, B.Sc., The Grammar School, Great Yarmouth.

1927 NEST, HUBERT CLIVE, M.A., Marlborough College, Marlborough, Wilts.

1919 †NEVILLE, ERIC HAROLD, M.A., B.Sc., F.R.A.S., sometime Fellow of Trinity College, Cambridge; Professor of Mathematics in the University of Reading; The Red House, Sonning-on-Thames, Berks. (Hon. Librarian, 1923- , President, 1934.)

1929 NEWBY, Mrs. MURIEL, M.A., 22, Thornton Hill, Wimbledon, London, S.W.19.

1926 NEWELL, PHILIP STANIFORTH, M.A., Gresham's School, Holt, Norfolk.

1934 NEWMAN, Miss FLORENCE EDITH, B.Sc., Hemel Hempstead Grammar School; Elesdene, Chaulden Lane, Boxmoor, Herts.

1923 NEWTON, ROBERT ENNIS, B.Sc., Queen Elizabeth's Grammar School, Darlington; Loreto, Barmpton Lane, Haughton-le-Skerne, Darlington, Co. Durham.

1920 NIGHTINGALE, Miss MABEL CONSTANCE, B.A., The Grammar School, Barton-upon-Humber, Lincs.

1925 NOBBS, CYRIL GORDON, M.A., City of London School, Victoria Embankment, London, E.C.4.

1909 †NUNN, Sir THOMAS PERCY, M.A., D.Sc., Hon.D.Litt., Hon.Litt.D., Hon.LL.D., Emeritus Professor of Education in the University of London, formerly Director of the University of London Institute of Education; The English Rooms, Funchal, Madeira. (President, 1917-1918.)

1936 NYE, Miss PHYLLIS MARY, B.Sc., L.R.A.M., Lady Eleanor Holles' School, Teddington, Middlesex; 5, Honeywell Road, Wandsworth Common, London, S.W.11.

1932 OBERLÉ, LUCIEN JOSEPH, M.A., Durban High School, St. Thomas Road, Durban, Natal, South Africa.

1934 O'GORMAN, Rev. Brother, Christian Brothers' College, Waverley, New South Wales, Australia.

1927 O'HARA, Rev. CHARLES WILLIBRORD, S.J., M.Sc., Manresa House, Roehampton, London, S.W.15.

1915 OLDFIELD, ARTHUR BENJAMIN, A.K.C., Principal of Pudsey Technical School, and Assistant Master in Pudsey Grammar School; Rydal Villas, Crawshaw Avenue, Pudsey, Nr. Leeds, Yorks.

1927 OLDHAM, DONALD H., B.Sc., County Secondary School, Midsomer Norton; 16, St. James Square, Bath, Somerset.

1931 O'LOGHLEN, Miss HELENA, B.Sc., Notre Dame High School, Southwark; 31, Elmhurst Road, Forest Gate, London, E.7.

1935 O'MEARA, GEORGE ALEXANDER, B.A., B.Sc., Worksop College, Worksop, Notts.

1922 ONSLOW, FRANCIS WILLIAM, B.Sc., Leamington College; Todwellyn, 160, Cubbington Road, Leamington Spa, Warwickshire.

1911 ORFEUR, HERBERT, A.K.C., 40, Ashling Crescent, Bournemouth, Hants.

1937 ORMANDY, Miss NORA LINDLEY, B.Sc., The High School, Sunderland; School House, Gray Road, Sunderland.

1935 OSBORN, Miss FRANCES ANNIE, B.Sc., Whyteleafe County School; 32, Godstone Road, Purley, Surrey.

1924 OSBORNE, CHARLES JOHN, M.Sc., Ryhope Secondary School; 3, Stratford Avenue, Sunderland, Co., Durham.

1936 OSBORNE, STEPHEN JOSEPH, B.A., Worksop College, Notts; 68, Ashburton Road, Croydon, Surrey.

1935 OSBORNE, WILLIAM HOWARD, B.A., Ampleforth College, York.

1936 OSBORNE, WINSTON SAMUEL, B.Sc., Boys' Secondary School, Caerphilly, Glam.

1935 OWEN, CLAUD DIGBY THORNTON, M.A., King Edward VI Grammar School, Totnes, South Devon.

1922 OWEN, Miss EDITH, M.A., Wade Deacon Grammar School, Widnes; 147, Birchfield Road, Widnes, Lancs.

1929 OWEN, STANLEY JOHN, B.A., Purley County School for Boys; 12, Broomhall Road, Sanderstead, Surrey.

1931 PAGE, Miss ALICE MARY, B.A., Purley County School for Girls; 10, Castle Street, Warwick.

1935 PAGE, ARTHUR, M.Sc., Ph.D., Borough Road College, Isleworth, Middlesex.

1909 PAGE, GEORGE FREDERIC, B.A., The High School, Newcastle, Staffs.

1937 PAGE, LEONARD, B.Sc., Acklam Hall Secondary School, Middlesbrough; 18, Broadgate Road, Linthorpe, Middlesbrough.

1926 PAKEMAN, Miss WINIFRED JULIA, The Central School for Girls, Derby; Birch House, 342, Abbey Street, Derby.

1923 PALMER, ALAN HENRY GILL, M.A., Mus.B., F.R.C.O., Grammar School, Great Yarmouth; The School House, Beaconsfield Road, Great Yarmouth, Norfolk.

1924 PANDAY, KASHI DATT, M.A., B.Sc., King Edward College, Amraoti, Berar, India.

1924 PARADINE, CHARLES GEORGE, M.A., Battersea Polytechnic, London, S.W.11.

1935 PARKER, WALTER THOMAS GEORGE, B.Sc., Boys' County School, Richmond, Surrey; 25, Redway Drive, Whitton, Twickenham, Middlesex.

1933 PARKES, CHARLES WILLIAM, M.A., B.Sc., H.M.I., Heaton Lodge, 17, Upper Oldfield Park, Bath, Somerset.

1922 PARKINSON, WILFRID, M.C., M.A., Headmaster of Bridlington School, Bridlington, Yorks.

1924 PARKINSON, WILLIAM GERALD, B.Sc., Rock Ferry High School; 44, Princes Boulevard, Higher Bebington, Cheshire.

1927 PARR, HAROLD EDWIN, M.A., Whitgift School, Croydon; 49, Beechwood Road, Sanderstead, Surrey.

1929 PARRATT, LEONARD ROBERT, B.Sc., Robert Atkinson Central School, Thornaby-on-Tees; 3, Cromwell Terrace, Thornaby-on-Tees, Stockton-on-Tees, Co. Durham.

1931 PARSLOW, LESLIE CHARLES, B.Sc., 42, Lowlands Road, Eastcote, Middlesex.

1930 PARSONS, GEORGE LEWINGDON, M.A., Merchant Taylors' School, Northwood, Middlesex; Peckwater, Eastcote Road, Pinner, Middlesex. (Hon. Secretary, 1936– .)

1913 PARTRIDGE, FRANCIS WILLIAM, M.A., The Grey High School, Port Elizabeth, Cape Colony, South Africa.

1903 PATERSON, WILLIAM ERNEST, M.A., B.Sc., 7, Donovan Avenue, Muswell Hill, London, N.10. (Hon. Librarian, 1922-3.)

1936 PATTERSON, D., M.A., M.Sc., Gore High School, New Zealand; Gore High Schol Hostel, Gore, Southland, New Zealand.

1935 PAULS, Miss FREDA MARGARET, B.Sc., Glanmôr Secondary School, Swansea; Eastbourne, Langland Bay, Swansea, Glam.

1924 PAYNE, FREDERICK WILLIAM, B.Sc., Workington County Secondary School; 57, Corporation Road, Workington, Cumberland.

1935 PAYNE, Miss IRENE, B.Sc., The Northern Secondary School, Mayfield Road, Portsmouth, Hants.

1930 PAYNE, Miss KATHLEEN ELEANOR, B.A., Parkfields Cedars Secondary School, Derby; Parkfields Cedars, Kedleston Road, Derby.

1926 PAYNE, Miss MAUDE FLORENCE, B.A., Portsmouth Northern Secondary School; 2, Eagle Tower, Lennox Road, Southsea, Hants.

1937 PAYNTER, JOHN RICHARD ELGAR, B.A., King's School, Canterbury; 8, Church Crescent, Friern Barnet, London, N.20.

1924 PEACOCK, JAMES, B.A., B.Sc., Brighton Grammar School; Rose Villa, Cross Road, Southwick, Sussex.

1933 PEAKER, GILBERT FAWCETT, M.A., H.M.I., 21, Henry's Avenue, Chingford Lane, Woodford Green, Essex.

1935 PEARCE, Miss VIOLET ELLA, B.Sc., The County High School for Girls, Abergavenny, Mon.; 22, Ashford Road, Swindon, Wilts.

1934 PEARCEY, THOMAS JOHN, Naval Ordnance Department, Admiralty; 26, Glenister Park Road, Streatham Vale, London, S.W.16.

1937 PEARCY, IVOR HARGRAVE, B.Sc., Beverley Grammar School; 30, Highgate, Beverley, Yorks.

1931 †PEARS, LESLIE RICHARDS, M.A., M.Sc., Ph.D., Merchant Taylors' School, Northwood, Middlesex.

1923 PEARSON, WILLIAM, F.S.A.A., 10, Duchy Crescent, Toller Lane, Heaton, Bradford, Yorks.

1923 PEAT, HENRY, M.A., South East Essex Technical College, Longbridge Road, Dagenham; 45, Dereham Road, Barking, Essex.

1930 PEATFIELD, Miss IDA LUCY, B.Sc., Colchester County High School for Girls; Greengates, Straight Road, Shrub End, Colchester, Essex.

1936 PEDLEY, ERIC RUSHBROOKE, B.A., King Edward's Grammar School, Aston; 26, The Manor, Willenhall, Staffs.

1936 PENDRY, Miss FRANCES MINNIE ANNE, M.Sc., County Secondary School, Clapton, London, E.5; 8, Wilton Court, Richmond, Surrey.

1936 PENGILLY, Miss KATHLEEN MABEL, B.Sc., Girls' High School, Oswestry; Bronwylfa, Mount Road, Oswestry, Salop.

1930 PERKINS, LEONARD CHARLES, B.Sc., B.Sc.(Econ.), F.R.Econ.S., Sutton Secondary School for Boys, Plymouth; 44, Chestnut Road, Plymouth, Devon.

1931 PERREN, Miss CATHERINE ELIZABETH, M.A., Reigate County Secondary School for Girls; Hatchlea, Millway, Reigate, Surrey.

1935 PETERSON, Mrs., The Hermitage, Geelong, Victoria, Australia.

1930 PHILLIPS, ALFRED GEORGE, B.Sc., Haverhill Secondary School; 117, Withersfield Road, Haverhill, Suffolk.

1923 PHILLIPS, Miss CHARLOTTE EMILY, B.A., King Edward VI Grammar School for Girls, Louth, Lincs.

1925 PHILLIPS, ERNEST, B.Sc., Abbey School, Barking; 103, Meads Lane, Seven Kings, Ilford, Essex.

1936 PHILLIPS, FREDERICK JOHN, 31, Cornford Grove, London, S.W.12.

1912 PIAGGIO, HENRY THOMAS HERBERT, M.A., D.Sc., Professor of Mathematics, University College, Nottingham; 5, Lenton Avenue, The Park, Nottingham.

1912 PICK, Miss MARION, M.A., B.Sc., Royal Holloway College, Englefield Green, Surrey.

1905 PICKEN, DAVID KENNEDY, M.A., Master of Ormond College, University of Melbourne; The Master's Lodge, Ormond College, Carlton, N.3, Victoria, Australia.

1912 PIGGOTT, HARRY EDWARD, M.A., Royal Naval College, Dartmouth, Devon.

1928 PINHORN, Miss IVY GRACE, M.Sc., The King's Warren School, Plumstead; 24, The Knoll, Hayes, Kent.

1933 PINNINGTON, Miss LUCY, B.Sc., Stoneycroft, Birkdale, Lancs.; 11, Oakdale Road, Waterloo, Liverpool.

1933 PITTWOOD, GEORGE ERNEST, M.A., Saffron Walden School, Saffron Walden, Essex.

1936 PLEDGE, HUMPHREY THOMAS, B.A., 73, Redcliffe Gardens, London, S.W.10.

1909 †PLUM, HARRY VICTOR, M.A., late Head Master of Kelly College, Tavistock, Devon; Rivington, Broadstone, Dorset.

1928 POCHIN, Mrs. AGNES (Math. Trip.), Head Mistress of Rutherford College Girls' School, Maple Terrace, Newcastle-on-Tyne, 4.

1920 POCOCK, Miss AMY MARGARET POCOCK, B.A., The College Secondary School, Swindon; 110, Goddard Avenue, Swindon, Wilts.

1925 POLLARD, Miss MABEL, B.Sc., Parliament Hill School, N.W.5; 32, Wellesley Road, Harrow, Middlesex.

1927 POOL, Miss WINIFRED MARY, B.A., County School for Girls, Bexhill-on-Sea; 9, Leasingham Gardens, Bexhill-on-Sea, Sussex.

1901 POOLE, ARTHUR WILLIAM, B.A., Birkenhead School; 57, Devonshire Road, Birkenhead, Cheshire.

1908 POOLE, Rev. HERBERT, B.A., Sedbergh School, Sedbergh Yorks.

1936 POPE, ALEC HEDLEY, M.Sc., University College, Cardiff, Glam.

1924 POPE, Miss BEATRICE MARY, B.Sc., C.M.S. Heep Yunn School, Kowloon City, Hong Kong.

1937 PORTEOUS, Miss MARY FINDLAY, B.A., King Edward VI Grammar School for Girls, Louth, Lincs.; Lochinver, 40, Fitzjames Avenue, East Croydon, Surrey.

1926 PORTER, MAURICE ANTHONY, M.A., King Edward's School, New Street, Birmingham; 36, Woodstock Road, Moseley, Birmingham.

1936 POTTER, JOHN FRANCIS, Henley-on-Thames Grammar School; 49, Harcourt Street, Newark, Notts.

1935 POTTER, Miss LOUISA, M.Sc., The Herts and Essex High School, Bishop's Stortford, Herts.

1918 POWELL, CHARLES EDWIN, M.A., Barnsley Grammar School; 5, Kensington Road, Barnsley, Yorks.

1937 PRAG, ADOLF, New Herrlingen School, Bunce Court, Faversham, Kent.

1928 PRATT, ARTHUR SIMPSON, M.A., M.Sc., Head Master of King Edward VI Grammar School, Nuneaton, Warwickshire.

1910 †PREBBLE, Miss DAISY, (Math. Trip.), Head Mistress of Kendrick Girls' School, Reading, Berks.

1912 PREBBLE, Miss EDITH JANE, Head Mistress of the High School, Crediton, North Devon.

1904 PRESTWICH, ALGERNON RICHARD, M.A., Liverpool College; 21, Sinclair Drive, Liverpool, 18.

1929 PRIOR, LESLIE ELLIOTT, M.Sc., University College, Nottingham; 57, Charnock Avenue, Wollaton Park, Nottingham.

1910 PRIOR, Miss THEODORA, B.Sc., The Training College, Hereford.

1931 PRITCHARD, INKERMAN THEODORE, B.A., H.M.I., c/o The Secretary, Board of Education, Whitehall, London, S.W.1.

1914 PROUDMAN, JOSEPH, M.A., D.Sc., F.R.S., Professor of Oceanography in the University of Liverpool; Stapley, Grassendale Park, Liverpool, 19.

1935 PROUT, HUGH KINGSLEY, M.A., Royal Naval College, Dartmouth; 13, Eastern Road, Brockley, London, S.E.4.

1936 PRYCE, DAVID GEORGE, B.Sc., Amman Valley County School, Ammanford; 10, Florence Road, Tirydail, Ammanford, Carm.

1910 PULLINGER, HENRY ROBERT, M.A., Head Master of the Royal Grammar School, Worcester; The Whiteladies, Worcester.

1910 PUNNETT, Miss MARGARET, B.A., formerly Vice-Principal of the University of London Institute of Education; 17, Gower Street, London, W.C.1. (Hon. Secretary, 1912- .)

1929 PYE, Miss FRANCES ANNIE, B.Sc., Howard Gardens, High School for Girls, Cardiff; 24, Kimberley Road, Roath Park, Cardiff, Glam.

1931 QUINTON, JOSEPH, M.C., B.A., The High School, Hanley, Stoke-on-Trent, Staffs.

1935 RACTLIFFE, J. F., M.Sc., Fishguard County School; 19, St. David's Place, Goodwick, Pembs.

1900 RADFORD, Rev. ERNEST MARSHALL, M.A., 33, Priest Hill, Caversham, Reading.

1935 RALPH, DAVID, M.Sc., Wintringham Secondary School, Grimsby; 191, Scarthoe Lane, Grimsby, Lincs.

1922 RALPH, Miss MARJORIE, B.A., The High School for Girls, Spalding, Lincs.

1905 RAMSEY, ARTHUR STANLEY, M.A., President and Lecturer of Magdalene College, Cambridge.

1936 RANDALL, GEORGE FREDERICK, B.A., Queen Elizabeth's Grammar School, Barnet, Herts.; 27, Stratford Road, Warwick.

1931 RANDALL, Miss GRACE FLORA, B.A., Rugby High School; 12a, Bilton Road, Rugby, Warwickshire.

1920 RANDALL, VINCENT, B.A., Leominster Grammar School; Roslyn, Green Lane, Leominster, Herefordshire.

1935 RASMUSSEN, Miss MAUDE LOUISE, B.Sc., Stroud High School; 12, King Street, Stroud, Glos.

1936 RAWSON, Miss MARGARET, B.A., St. Aloysius' Convent, Clarendon Square, London, N.W.1; 101, Hazellville Road, London, N.19.

1936 RAY, ALBERT GEORGE, B.A., Thorne Grammar School, Doncaster, Yorks.

1929 RAYBOULD, Miss ETHEL HARRIETT, M.A., Lecturer in Mathematics, University of Queensland, Brisbane, Queensland, Australia.

1930 RAYNER, JOHN MAXWELL, B.Sc., F.Inst.P., Geological Survey, New South Wales, Department of Mines, Sydney New South Wales, Australia.

1935 RAYNER, SYDNEY HERBERT, M.A., Sir George Monoux Grammar School, Walthamstow, E.17; 25, Pole Hill Road, King's Head Hill, Chingford, London, E.4.

1933 RAYNHAM, EDWARD GASTON, B.Sc., Raynes Park County School, Merton, London, S.W.20.

1919 READ, Miss ETHEL MARY, B.Sc., The King's Norton Secondary School for Girls, Birmingham; 50, Bunbury Road, Northfield, Birmingham.

1905 READE, JOHN ALFRED DEARDEN, M.A., St. Edmund's School, Canterbury; Gorsefield, Giles Lane, Canterbury, Kent.

1927 REECE, FREDERICK WILLIAM, M.Sc., Liverpool Institute; 29, Parkside, Egremont, Wallasey, Cheshire.

1935 REES, JOHN ELWYN, M.A., Sudbury Grammar School; 66, Friars Street, Sudbury, Suffolk.

1935 REES, WILLIAM LLEWELYN, B.Sc., Garw Secondary School, Pontycymer, Glam.; 3, School Terrace, Blaengarw, Nr. Bridgend, Glam.

1912 REEVE, Miss KATHERINE (Math. Trip.), Head Mistress of the Girls' High School, Normanton; 107, Church Lane, Normanton, Yorks.

1926 REEVE, WILLIAM DAVID, Ph.D., Professor of Mathematics, Teachers' College, Columbia University; 445, Riverside Drive, New York City, U.S.A.

1935 REEVES, Miss LILIAN ELLA MARY, B.Sc., Bangor County School for Girls; 10, Menai View, Bangor, North Wales.

1930 REEVES, PHILIP HOWARD, B.Sc., Canton High School for Boys, Cardiff; 42, Tair Erw Road, Whitchurch, Cardiff, Glam.

1927 REID, ALEXANDER, M.A., B.Sc., Principal of Government Training College and Associate Professor of Education in University College, Pietermaritzburg, Natal, South Africa.

1934 REID, Miss DOROTHY GRAINGER, M.A., Queen Mary's High School for Girls, Walsall; 241, Sutton Road, Walsall, Staffs.

1920 RENWICK, JOHN ERNEST, M.A., Bedford School, Bedford.

1935 RETTER, CECIL FRANCIS, M.A., B.Sc., Highbury County School, N.5; 90, Blake Road, New Southgate, London, N.11.

1934 REYNOLDS, CHRISTOPHER, B.Sc., Secondary School, Port Talbot; 29, Grange Street, Port Talbot, Glam.

1935 RICE, Miss WINIFRED ANNIE, B.A., Watford Central School and Pupil Teachers' Centre; 25, Granville Road, Watford, Herts.

1934 RICHARDS, ALBERT GEORGE GRANSTON, B.Sc., Rendcomb College, Cirencester; Rendcomb, Cirencester, Glos.

1898 RICHARDS, CHARLES HENRY, M.A., Sunnyside, Martock, Somerset.

1920 †RICHARDS, Miss EFFIE MARION, B.A., County School for Girls, Sittingbourne; St. Giles, Lovers Walk, Sittingbourne, Kent.

1936 RICHARDS, IDRIS GWYN, B.Sc., Llanelly County School; 7, Carrick Avenue, Llanelly, Carmarthenshire.

1935 RICHARDS, JOHN BENJAMIN, M.A., B.Sc., Oldbury County High School, Worcs.; 36, Warley Road, Langley, Birmingham.

1935 RICHARDS, Miss MARY WAINWRIGHT, M.A., Benenden School, Cranbrook; Clevelands, Benenden, Cranbrook, Kent.

1930 RICHARDS, NEVILLE, B.Sc., Lewis' School, Pengam, Glam.

1934 RICHARDSON, Lt.-Col. ARCHIBALD REED, D.S.O., B.Sc., A.R.C.S., Fellow of University College, London, Professor of Mathematics, University College, Swansea; High Mead, The Poplars, Sketty, Swansea, Glam.

1914 RICHARDSON, ARTHUR VERNON, M.A., Hon.D.C.L., Professor of Mathematics in Bishop's College, Lennoxville, Province of Quebec, Canada.

1937 RICHARDSON, GEORGE, B.A., Bromley County School; 30, Woodside Road, Bickley, Kent.

1925 RICHARDSON, SAMUEL, B.Sc., Holyhead County School; 29, Tan y Bryn Road, Holyhead, Anglesey.

1930 RICHMOND, CYRIL AUBREY, M.A., Northampton School; 18, Bostock Avenue, Northampton.

1901 RICHMOND, HERBERT WILLIAM, M.A., Hon.LL.D., F.R.S., Fellow of King's College, Cambridge; King's College, Cambridge.

1934 RICKETTS, CYRIL CHARLES, B.Sc., Ampleforth College, Yorks.

1936 RICKETTS, WILLIAM JOHN, B.A., Ormiston, Campbell College, Belfast.

1910 RIGBY, Miss KATE WINIFRED, M.A., North London Collegiate School; 12, Fellows Road, Hampstead, London, N.W.3.

1937 RIGBY, WILLIAM JOSEPH, M.A., Ilford County High School for Boys; 9, Harpenden Road, London, E.12.

1924 RILEY, ALLAN WOODBURNE, B.Sc., Head Master of the Edward Shelley Central School, Walsall; 56, Broadway North, Walsall, Staffs.

1937 RILEY, Miss MIRIAM JESSIE, B.A., The High School, Hamilton, Waikato, New Zealand.

1927 RISDON, GEORGE WALTER ALBERT SHIER, 11, Victoria Street, London, S.W.1.

1935 RITCHIE, HARRY GEORGE, late Capt. R.F.A., Cargillfield School, Barnton; Craig Durley, Queensferry Road, Barnton, Midlothian.

1922 ROBBINS, FRANK, F.R.A.S., The University of London Observatory, Mill Hill Park, London, N.W.7.

1930 ROBERTS, DONALD TEMPLE, B.Sc., Woodhouse Grove School, Apperley Bridge, Bradford; 103, Apperley Road, Idle, Bradford, Yorks.

1929 ROBERTS, JOHN CLARKE, M.A., King Edward's School, Bristol Road, Birmingham, 5.

1936 ROBERTS, JOHN DANIEL, B.Sc., County School, Narberth; 11, Northfield Road, Narberth, Pembrokeshire.

1905 ROBERTS, WALTER MEAKIN, O.B.E., M.A., Professor of Mathematics at Royal Military Academy, Woolwich; 22, Westmount Road, Eltham, London, S.E.9.

1936 ROBERTSON, Miss GRACE McCALLUM, Struan, 10, Park Road, Broxburn, West Lothian.

1905 ROBINSON, FRANK EDMUND, M.A., 57, Lonsdale Road, Barnes, London, S.W.13.

1924 ROBINSON, GEORGE, M.A., B.Sc., 542 14th Avenue West, Calgary, Alberta, Canada.

1925 ROBINSON, RICHARD THOMAS, M.A., B.Sc., formerly Head Master of the Grammar School, Burton-on-Trent; 115, Shobnall Road, Burton-on-Trent, Staffs.

1912 †ROBSON, ALAN, M.A., Marlborough College, Wilts.

1928 ROBSON, Miss ANNABEL, B.Sc., Girls' Secondary School, Brighouse; 1, Lyndhurst Avenue, Brighouse, Yorks.

1923 ROBSON, LEONARD CHARLES, M.C., M.A., B.Sc., Head Master of Sydney Church of England Grammar School, North Sydney, New South Wales, Australia.

1924 ROCK, GEORGE EDWIN, B.Sc., Sir Roger Manwood's Grammar School, Sandwich; Shirley, Manwood Road, Sandwich, Kent.

1931 ROEBUCK, FREDERICK ALBERT, Swanbourne House School, Swanbourne, Bletchley, Bucks; 69, King's Avenue, Greenford Park, Middlesex.

1926 ROGERS, Miss MURIEL MARGARET, M.A., The Training College, Truro, Cornwall.

1925 ROLFE, CECIL GORDON, B.A., Royal Technical College, Salford; 39, Victoria Road, Pendleton, Manchester.

1924 ROLLETT, ARTHUR PERCY, B.Sc., Sevenoaks School; Churchfield, Oak Lane, Sevenoaks, Kent.

1936 ROPER, Miss GWENDOLIN MARJORIE, B.A., M.A., City and County School for Girls, Chester; Corabor, Burton Joyce, Nottingham.

1936 ROSE, FRANK PETER, B.A., King Edward VI School, Stourbridge; 3, Brook Street, Stourbridge, Worcs.

1929 ROSE, GEORGE FREDERICK, M.A., M.Sc., Principal of the Cambridgeshire Technical School, Collier Road, Cambridge.

1926 ROSEVEARE, MARTIN PEARSON, M.A., H.M.I., Rydal House, Highgate Avenue, Fulwood, Preston, Lancs.

1923 ROSEVEARE, RICHARD VICTOR HARLEY, M.C., M.A., Wellington College, Berks.

1890 ROSEVEARE, WILLIAM NICHOLAS, M.A., late Fellow of St. John's College, Cambridge; formerly Professor of Mathematics, Natal University College, Maritzburg, Natal, South Africa; North Parade, Monmouth.

1935 ROSS, CHARLES, M.Sc., Christ's College, Finchley; 17a, Station Road, Wealdstone, Harrow, Middlesex.

1922 ROSS, JAMES, STIVEN, M.A., B.Sc., Westminster Training College; 130, Horseferry Road, Westminster, London, S.W.1.

1920 ROTHERHAM, Miss ELSIE MARGARET, B.A., Clapham County Secondary School for Girls; 29, Ardoch Road, Catford, London, S.E.6.

1934 ROWAN, Miss EILEEN HILL WILSON, B.A., M.A., 32, Belsize Road, London, N.W.6.

1928 ROWE, CHARLES HENRY, M.A., M.Sc., Fellow of Trinity College, Dublin, and Erasmus Smith Professor of Mathematics in the University of Dublin; 38, Trinity College, Dublin.

1926 ROWLEY, JOHN SELWYN, M.A., Victoria College, Jersey; Pembroke Lodge, Patier Lane, St. Saviour, Jersey, Channel Islands.

1922 ROXBY, BERTRAM GORDON, M.A., Salford Grammar School for Boys; Coid-Ithel, Station Road, Marple, Nr. Stockport, Cheshire.

1922 RUDDLE, Miss PHYLLIS ELINOR, B.A., Doncaster High School; 20, St. Mary's Road, Doncaster, Yorks.

1936 RUSBRIDGE, Miss MARJORIE JESSIE, B.A., Dover County School for Girls; 61, Castle Avenue, Dover, Kent.

1924 RUSCOE, REGINALD GUY, M.A., Head Master of Hereford High School for Boys; Mount Craig, Broomy Hill, Hereford.

1924 RUSSELL, EPHRAIM, M.A., B.Sc., F.R.Hist.S., Head Master of the Verdin Grammar School, Winsford, Cheshire.

1930 RUTHERFORD, DANIEL EDWIN, M.A., B.Sc., D.Math., F.R.S.E., United College, St Andrews University; 8, Moredun Terrace, Perth, Scotland.

1937 RUTLAND, VERNON DAVID HUBERT, B.Sc., Stretford Grammar School; 25, Great Stone Road, Gorse Hill, Stretford, Lancs.

1909 RYAN, Miss CECILIA, M.A., B.Sc., Lecturer in Mathematics, Training College, Carysfort Park, Blackrock, Dublin.

1920 SADLER, LESLIE, M.A., Head Master of the Wheelwright Grammar School, Dewsbury, Yorks.

1919 SAMPSON, ARTHUR JOHN, B.A., Ealing County School for Boys; 46, Camborne Avenue, West Ealing, London, W.13.

1933 SANDERS, Miss EDITH MARJORIE, M.A., Bedford High School; 97, Ashburnham Road, Bedford.

1937 SANDERSON, Miss MARY SHELLEY, B.Sc., County High School for Girls, West Kirby, Cheshire; 31, Cambrian View, Chester.

1915 SANDON, FRANK, M.A., F.S.S., Head Master of Plymouth Corporation Grammar School; Gray Garth, Crownhill, Devon.

1930 SARGENT, Miss WINIFRED LYDIA CRUNDEN, M.A., Royal Holloway College, Englefield Green, Surrey.

1929 SAUNDERS, Miss NANCY LOUISE, B.Sc., Blyth Secondary School, Norwich.

1910 SAVERY, HERBERT, M.A., Welland, Marlborough, Wilts.

1928 SAWYER, ALAN ERNEST, B.Sc., Ranmore, Woodmansterne Lane, Banstead, Surrey.

1912 SAXELBY, CHARLES HAROLD, M.Sc., Rivington and Blackrod Grammar School, Lancs.; 63, Uphill Grove, Mill Hill, London, N.W.7.

1935 SAXELBY, FRANK MOULTON, M.Sc., B.A., 161, Uphill Grove, Mill Hill, London, N.W.7.

1930 SAYERS, Miss KATHERINE ISABEL, M.A., Lowther College, Abergele, North Wales.

1935 †SCHOFIELD, HARRY, M.A., St. Albans School; Langley, Charmouth Road, St. Albans, Herts.

1931 SCHREIBER, EDWIN WILLIAM, M.A., Associate Professor of Mathematics in the Western Illinois State Teachers' College, Macomb, Illinois, U.S.A.; Secretary-Treasurer of the National Council of Teachers of Mathematics, U.S.A.; 719, W. Adams Street, Macomb, Illinois, U.S.A.

1936 SCOTT, ARTHUR, B.Sc., Boulevard Secondary School, Hull; 56, Redcross Street, Leicester.

1933 SCOULAR, Miss ELIZABETH McINDOE EILLY, M.A., B.Sc., Girls' High School, Lincoln; 28, Curle Avenue, Lincoln.

1922 .SCREETON, NORMAN HAROLD, B.Sc., Head Master of Hemel Hempstead Grammar School; Brooke, 22, Hillfield Road, Hemel Hempstead, Herts.

1936 SCUDAMORE, Miss KATHLEEN, B.A., Brighton and Hove High School; The Beeches, Cambridge Road, Teddington, Middlesex.

1932 SEDDON, Mrs. WINIFRED LAURA, (Math. Trip.), Manchester High School for Girls; 27, Milton Crescent, Cheadle, Cheshire.

1936 SEGEDIN, CECIL MARIN, M.Sc., 36a, Valley Road, Mount Eden, Auckland, S.2, New Zealand.

1934 SELBY, Miss FLORENCE HILDA, B.A., The Manning School, Nottingham; 31, Millicent Road, West Bridgford, Nottingham.

1924 †SEMPLE, Rev. SAMUEL HANNA, O.B.E., M.A., B.D., Principal of St. Luke's School, Haifa, Palestine.

1928 SEXTON, Miss ELIZA CATHERINE, M.A., County Secondary School for Girls, Dalston; 23, Castleton Road, Upper Walthamstow, London, E.17.

1934 SEYMOUR, Miss PHYLLIS, B.Sc., Sydenham County Secondary School; Fincham Lodge, Burgh Heath, Surrey.

1932 SHAH, Principal N. M., M.A., F.R.A.S., Principal and Professor of Mathematics, Maganlal Tharkordas Balmukunddas College, Surat, India.

1925 SHARMAN, MATTHEW STANTON, M.A., M.Sc., University High School, Storey Street, Parkville, Victoria, Australia.

1909 SHARMAN, Miss MAUD, B.A., Hornsey High School; 97, Old Park Avenue, Enfield, Middlesex.

1935 SHAVELSON, Miss ALICE, B.Sc., The North Paddington Central School, Kilburn Lane, W.10; 21, Howitt Road, Haverstock Hill, London, N.W.3.

1930 SHAW, Miss MARION, B.Sc., Abbeydale Girls' Secondary School; 46, Edgedale Road, Millhouses, Sheffield, 7, Yorks.

1926 SHAW, Miss MARY, B.A., Ladies' College, Cheltenham, Glos.

1935 SHAW, THOMAS TAYLOR, M.A., Head Master of the Grammar School, Macclesfield, Cheshire.

1920 †SHEARMAN, DONALD JAMES, B.A., B.Sc., Head Master of the Metropolitan Business College; 6, Dalley Street, Sydney, New South Wales, Australia.

1930 SHEEN, GEOFFREY, M.A., The Grammar School, Wolverhampton, Staffs.

1921 SHELDON, ERNEST WILSON, M.A., Ph.D., Professor of Mathematics, University of Alberta, Edmonton, Alberta, Canada.

1932 SHEPPARD, NORMAN FLEETWOOD, B.Sc., King Alfred School, Hampstead, London, N.W.3.

1937 SHEPPEE, HUBERT V., B.Sc., Clapham College; 33, Malwood Road, London, S.W.12.

1921 †SHERRIFF, Miss CATHERINE WILSON McKENZIE, M.A., B.Sc., Froebel Educational Institute, Grove House, Roehampton Lane, London, S.W.15.

1937 SHILSTON, Miss GLADYS MURIEL, B.A., Church High School, Newcastle-on-Tyne; 80, Norfolk Avenue, Sanderstead, Surrey.

1925 SHORTRIDGE, Miss ALICE, M.A., Tynemouth Municipal High School; 2, Parkside Crescent, Tynemouth, Northumberland.

1930 SHOTLANDER, LIONEL, M.A., c/o The Australian Temperance and General Mutual Life Assurance Society, Ltd., Collins and Russell Street, Melbourne, C.1, Victoria, Australia.

1908 SHOVELTON, SYDNEY TAVERNER, M.A., University of London, King's College; formerly Fellow of Merton College, Oxford; 8, Holly Park Gardens, Finchley, London, N.3.

1935 SHUKER, Miss ENID EMILY, B.Sc., George Dixon Girls' Secondary School; 82, Aldridge Road, Perry Barr, Birmingham, 20.

1935 SHUTTLEWORTH, Mrs. EDITH, M.A., Queen's College, London, W.1; 18, Grove Road, Northwood, Middlesex.

1899 SIDDONS, ARTHUR WARRY, M.A., formerly of Harrow School; sometime Fellow of Jesus College, Cambridge; Orchard House, Roxeth Hill, Harrow-on-the-Hill, Middlesex.

1927 SIDE, Miss GLADYS AMY, B.Sc., Devonport Secondary School for Girls; 26, Onslow Road, Peverell, Plymouth, Devon.

1926 SILOW, Miss ETHEL MAUD, B.A., St. Winifred's, Eastbourne, Sussex; 3, Holders Hill Drive, Hendon, London, N.W.4.

1928 SIMONDS, EUGENE FRANCIS, B.Sc., Ph.D., Professor of Mathematics in the University of Queensland, Brisbane, Queensland, Australia.

1931 SIMONS, BERNARD, B.Sc., Acton Technical College; 36, Staverton Road, Brondesbury Park, London, N.W.2.

1933 SINCLAIR, GEORGE INNES, M.Sc., Ph.D., Brockley County School, S.E.4; 12, Allenby Road, Forest Hill, London, S.E.23.

1936 SINKINSON, ALAN TAYLOR, M.A., Sir Thomas Rich's School, Gloucester; Burleigh, Bannwood Avenue, Gloucester.

1922 SISSON, GEOFFREY ROY, M.A., Royal Military Academy, Woolwich; 52 Handen Road, Lee, London, S.E.12.

1937 SIVETER, JOHN, 25 Handley Street, Wednesbury, Staffs.

1926 †SKEWES, STANLEY, M.A., B.Sc., Lecturer in Cape Town University; Pure Mathematics Department, The University, Cape Town, South Africa.

1925 SKINNER, JOHN CECIL, M.A., Organising Inspector of Continuation Schools, Bradford Education Committee; 1, Fairfield Avenue, Edgware, Middlesex.

1923 SLACK, ERNEST HENRY, A.C.P., Chesterfield Grammar School; Dona Garth, 102, Peveril Road, Chesterfield, Derbyshire.

1936 SLATER, ANDREW M., B.A., Woodlands, Deganwy, N. Wales.

1921 SMALE, Miss SYBIL EVELYN BERTHA, M.A., Bury Grammar School for Girls; 3, Wellington Gardens, Grange Road, Bury, Lancs.

1902 SMART, EDWARD HOWARD, M.A., Birkbeck College; Amberley, Dunoon Road, Forest Hill, London, S.E.23.

1921 SMEAL, GLENNY, M.Sc., University of Leeds; 4, Montpelier, Leeds, 6, Yorks.

1936 SMITH, ARTHUR ALBERT, Sevenoaks School, Kent; 44, Kilburn Lane, London, W.10.

1926 SMITH, ALFRED LIONEL CHARLES, M.A., B.Sc., The Crypt School, Gloucester; 21, King Edward's Avenue, Gloucester.

1935 SMITH, ARTHUR McLEISH, B.A., Lawrence Sheriff School, Rugby, Warwickshire.

1929 SMITH, ALFRED STANHOPE DOUGLAS, B.Sc., Erith County School, Belvedere, Kent; 476, Green Lane, New Eltham, London, S.E.9.

1932 SMITH, ARNOLD, M.A., Maltby Grammar School, Rotherham, Yorks.

1926 SMITH, Miss DOROTHY ROBINA, M.A., Head Mistress of the Collegiate School for Girls, Leicester; 25, Lincoln Street, Leicester.

1925 SMITH, EDGAR PERCY CLIFFORD, B.A., L.C.P., County Secondary School, Slough; Werneth, Temple Road, Windsor, Berks.

1933 SMITH, EDWARD DUDLEY, M.A., Marlborough College, Wilts.

1928 SMITH, Mrs. ELSIE WARDLEY, M.Sc., Kenton Lodge Training College; 10, Wellesley Terrace, Newcastle-upon-Tyne.

1927 SMITH, ERNEST VICTOR, M.A., King Edward's School, Birmingham.

1924 SMITH, HENRY STANLEY, M.Sc., Boys' High School, Westcliff-on-Sea; Glenesk, Western Road, Leigh-on-Sea, Essex.

1936 SMITH, HERBERT CECIL, M.A., The Army College, Heath End, Farnham; Lane End, The Sands, Farnham, Surrey.

1934 SMITH, JAMES H., B.A., Huddersfield Technical College; Springwood, Hall, Huddersfield, Yorks.

1934 SMITH, JAMES STANLEY, B.Sc., The Grammar School, Chadderton; 29, Moreton Street, Chadderton, Lancs.

1936 SMITH, JOE WILLIAM ASHLEY, B.A., B.Sc., The High School Newcastle, Staffs.

1936 SMITH, JOHN, Headmaster, Junior and Infants' School, Ward End, Birmingham; 221, Kingsbury Road, Erdington, Birmingham.

1923 SMITH, JOSEPH, B.Sc.., Mus.Bac., L.R.A.M., Langham Tower Training College, Supervisor of Music to Sunderland Schools; 22, Cleveland View, Seaburn, Sunderland.

1935 SMITH, JOSEPH ERIC, M.A., Newton-in-Makerfield Grammar School; Thornton, Mannering Gardens, Westcliff-on-Sea, Essex.

1934 SMITH, K. W. A., B.Sc., King's College, Adelaide, South Australia.

1933 SMITH, Miss MARY CICELY, B.Sc., Winckley Square, Secondary School, Preston; 120, Powis Road, Ashton-on-Ribble, Preston, Lancs.

1935 SMITH, PERCY JAMES, B.Sc., The County School, Willesden; 13, Blenheim Road, North Harrow, Middlesex.

1924 SMITH, SIDNEY LINAKER, M.A., B.Sc., Berkhamsted School; Hartland, Anglefield Road, Berkhamsted, Herts.

1935 SMITH, WILLIAM ARTHUR CORNELIUS, M.Sc., Nelson College, Nelson, New Zealand.

1927 SMYTH, THOMAS HUTCHINSON, M.A., Eton College, Windsor, Berks.

1924 SNELL, KENNETH SCOTCHBURN, M.A., Harrow School; 2, Kennet House, Harrow Park, Harrow, Middlesex.

1936 SODEN, HAROLD CHRISTIAN, Packwood Haugh (Preparatory School), Hockley Heath, Warwickshire.

1934 SOPER, CYRIL HECTOR GIBSON, M.A., B.Sc., Vinney Bank, Honiton Road, Exeter, Devon.

1933 SOPWITH, ARTHUR, M.A., Bradfield College, Berkshire.

1923 SOWDEN, Miss MARY FLORENCE, B.A., Scarborough Girls' High School; 13, Manor Gardens, Scarborough, Yorks.

1931 SPAFFORD, LOUIS WILLIAM, B.Sc., Emanuel School, Wandsworth Common, London, S.W.11.

1913 †SPARLING, HART PHILIP, M.A., Rugby School; Temple Observatory, Rugby.

1935 SPECK, GERALD, 75, Alfred Street, Gloucester.

1936 SPENCER, Miss MARY LOUISA, B.Sc., Wirral County School for Girls, Heath Road, Bebington, Cheshire.

1935 SPENCER, THOMAS ARTHUR JAMES, M.Sc., Central Foundation Boys' School, E.C.2; 17, Cranston Park Avenue, Upminster, Essex.

1934 SPENSLEY, LEONARD ROBERT, B.Sc., The King's School, Pontefract; Elmhurst, 22, Carleton Crescent, Pontefract, Yorks.

1935 SPICER, ALEXANDER WILLIAM ALLEN, B.Sc., Superintendent of Education, Nigeria; c/o Education Office, Lagos, Nigeria.

1886 †SPIERS, ARTHUR HOOD, M.A., 72, Carlton Hill, St. John's Wood, London, N.W.8.

1931 STANLEY, Miss GERTRUDE KATHERINE, M.Sc., B.Sc., Westfield College (University of London), Hampstead, London, N.W.3.

1922 STARK, Miss GLADYS ROBINA, B.A., Kirby Secondary School, Middlesbrough; 107, Thornfield Road, Linthorpe, Middlesbrough, Yorks.

1934 STARKEY, Miss DAISY MAY, M.Sc., North London Collegiate School; 153, Davenport Road, Catford, London, S.E.6.

1932 STAYNOR, ERYX VERE, M.A., Victoria School, Kurseong, P.O. Dow Hill, D.H. Railway, Bengal, India.

1920 STENHOUSE, Miss S. E., B.A., Wyggeston Girls' School, Leicester; 14a, Alexandra Road, Leicester.

1924 STEPHENS, Miss MAY OLIVE, B.A., Fairfield High School, Manchester.

1934 STEPHENSON, CHARLES WILLIAM, M.Sc., The High School for Boys, Chichester; Wollaton, Parklands Road, Chichester, Sussex.

1936 STEPHENSON, GEORGE HENRY BERNARD, B.Sc., Portsmouth Southern Secondary School for Boys; 11, Pelham Road, Southsea, Hants.

1936 STEPHENSON, Captain HUGH PERCIVAL, English Preparatory School, Champ Fleuri, Glion, Switzerland.

1923 STEPHENSON, STUART, M.A., Head Master of the Boys' Grammar School, Gregory Terrace, Brisbane, Queensland, Australia.

1937 STEVENS, GILBERT HENRY, (Math. Trip.), County Grammar School, Wolstanton; 46, Kingsway West, Newcastle, Staffs.

1930 STEVENS, HAROLD WITHERS, M.A., 87, St. Michael's Hill, Bristol, 2.

1935 STEVENSON, Miss ELIZABETH HELEN, B.Sc., Training College, The Close, Salisbury, Wilts.

1926 STEWART, JAMES WILLIAM, B.A., The High School, Kelso; Lyme Cottage, Kelso, Roxburgh, Scotland.

1924 STIMSON, Miss CLARA, M.A., Furzedown Training College; 21, Walpole Street, Chelsea, London, S.W.3.

1925 STIMSON, Miss MARGARET, M.A., Ph.D., Head Mistress, Stoke Damerel Secondary School for Girls, Devonport; 39, Brean Down Road, Peverell, Plymouth, Devon.

1887 STOCKER, WILLIAM NELSON, M.A., Fellow and Lecturer, Brasenose College, Oxford.

1937 STOKES, CHRISTOPHER WILLIAM, M.A., H.M.I., 65, Farnaby Road, Bromley, Kent.

1932 STOKES, Miss EDITH HANNAH, B.Sc., The High School for Girls, Hereford; Camber, College Road, Hereford.

1937 STOKES, Miss EUPHEMIA MARGARET, B.Sc., St. Christopher's Training College, Vepery, Madras, S. India.

1933 STONE, REGINALD HAROLD, B.Sc., County High School, Eastleigh, Hants.; Penthryn, Baddesley Road, Chandlers Ford, Hants.

1927 STOTT, JAMES, M.A., B.Sc., Head Master of Blandford Grammar School; The Old House, Blandford, Dorset.

1926 STOTT, WALTER. 40, Priory Gardens, Highgate, London, N.6.

1929 STRACHAN, Miss ALICE MARY, M.A., County School for Girls, Chatham, Kent.

1910 STRACHAN, JAMES, B.Sc., M.A., H.M. Inspector of Schools; Westfield Lodge, Bishop's Stortford, Herts.

1913 STRAIN, THOMAS GREER, M.A., 23, St. Martin's Avenue, Shanklin, Isle of Wight.

1909 †STRAITON, GEORGE IRVINE, B.Sc., The Academy, Montrose; Morven, Union Place, Montrose, Angus, Scotland.

1932 STRATTON, ROBERT TARBET, M.A., B.Sc., Ayr Academy; Kalani, 2 Arrol Drive, Ayr, Scotland.

1928 STRAWSON, GEORGE EDWARD, M.Sc., Ranelagh School, Bracknell; Linthorpe, Warfield, Bracknell, Berks.

1932 STREET, REGINALD OWEN, M.A., M.Sc., Professor of Mathematics, Royal Technical College, Glasgow, C.1.

1935 STRICKLAND, Lt.-Col. NOEL, M.A., Repton School; The Cross, Repton, Derbyshire.

1927 STRIPP, ALFRED GEORGE, B.Sc., Sir Walter St. John's School, Battersea; 8, Bushey Way, Park Langley, Beckenham, Kent.

1926 STRONG, WILLIAM RICHARD, F.I.A., F.S.S., F.C.I.S., F.C.A.S., 4, Sheringham, Cotham Road, Kew, Melbourne, E.4, Victoria, Australia.

1937 STROUD, LESLIE JOHN, B.Sc., Teignmouth Grammar School, Devon; Hazel Bank, Rowledge, Farnham, Surrey.

1932 STURGEON, ROBERT WALLACE, F.I.A., Royal Insurance Company, Ltd., 1, North John Street, Liverpool.

1924 STYLER, HAROLD VICTOR, M.A., Dulwich College; Cobo, Repton Road, Orpington, Kent.

1936 SUDBURY, Miss DORA NEVILLE, B.Sc., 2, Forster Road, Beckenham, Kent.

1922 SUNDERLAND, JOHN, B.Sc., Hanson High School for Boys, Bradford; 1, Grenfell Terrace, Bradford Moor, Bradford, Yorks.

1930 SUTCLIFFE, Miss EDITH WINIFRED, Maynard School, Exeter.

1903 SUTTON, FREDERICK SAMUEL, M.A., Bishop's Stortford College; Waytefield, Bishop's Stortford, Herts.

1936 SWAINE, KENNETH BRUCE, M.A., Wanstead County High School, Wanstead, E.11; 77, Castle View Gardens, Ilford, Essex.

1934 SWAN, FREDERICK JAMES, M.A., B.Sc., Hackney Downs School, Clapton, E.5; 51, Ridge Road, Winchmore Hill, London, N.21.

1909 SWANN, ALFRED, B.A., Shandon, 11, Fuller's Road, Woodford, London, E.18.

1919 SWANN, Miss KATHLEEN MARY, B.A., Bishop Fox's Girls' School, Taunton; The Old Elms, Taunton, Somerset.

1935 SWEET, Miss DOROTHY ADELA RACHEL, M.A., Headmistress of Leamington High School, Beauchamp Hall, Leamington, Warwickshire.

1932 SWINDELL, Miss PHYLLIS MABEL, B.Sc., Leeds Girls' High School; 11, Hemington Avenue, Friern Barnet, London, N.11.

1931 SWINDEN, BENJAMIN ALFRED, B.A., Town and Country School, Northampton; Westbar, Chipsey Avenue, Northampton.

1931 SWINDEN, LEONARD ALFRED, B.Sc., Trinity County School, Wood Green, N.; 8, The Close, Old Southgate, London, N.14.

1931 SWIRLES, Miss BERTHA, M.A., Ph.D., Lecturer in Mathematics in the University of Manchester.

1932 SYER, FREDERICK JOHN DANIEL, B.A., University High School, Melbourne, N.2; 61, Fitzwilliam Street, Kew, E.4, Victoria, Australia.

1931 †SYMONS, LLOYD ALFRED GRIGG, B.A., Collegiate School of St. Peter, St. Peter, Adelaide, South Australia.

1930 SYNGE, JOHN LIGHTON, M.A., Sc.D., Professor of Applied Mathematics, University of Toronto, Canada.

1936 TALBOT, BASIL LYNCH, M.A., St. Peters, Seaford, Sussex.

1920 TALBOT, JOSEPH WILLIAM, B.A., The Magnus Grammar School, Newark; Aingarth, Grantham Road, Radcliff-on-Trent, Notts.

1903 TANNER, Miss MARIANNE LOUISA, B.A., Broughton High School, Salford; 9, Lowther Road, Crumpsall, Manchester, 8.

1925 †TARVER, JOHN ERNEST, B.A., Royal Grammar School, Lancaster; Stoneleigh, Derwent Road, Lancaster.

1934 TAWADROUS, GAD, B.Sc. Sanieh Secondary School, Cairo, Egypt.

1922 TAYLOR, ALBERT JAMES, M.A., M.Sc., Ph.D., Whitgift Middle School, Croydon; 30, Manor Gardens, Purley, Surrey.

1936 TAYLOR, BERNARD HORACE THEODORE, B.Sc., Thorne Grammar School, Nr. Doncaster; 4, Marsdin Grove, Thorne, Doncaster, Yorks.

1924 TAYLOR, Miss CATHERINE, M.A., B.Sc., Training College, Mount Pleasant, Liverpool, 3.

1930 TAYLOR, DAVID GLADSTONE, M.A., D.Sc., Lecturer in Pure Mathematics, University College, Cardiff; St. John's, 23, Southcourt Road, Penylan, Cardiff, Glam.

1936 TAYLOR, Miss FAITH, B.Sc., 10, Mount Avenue, Ealing, London, W.5.

1937 TAYLOR, JACK ALFRED, M.Sc., The Grammar School, Beverley, E. Yorks.

1937 TAYLOR, Miss MARY, M.Sc., Great Yarmouth High School; 10, Albert Square, Great Yarmouth.

1936 TAYLOR, Miss MILDRED BURELLA, M.A., Cambridge Training College; 1, Stanley Gardens, London, W.11.

1937 TAYLOR, REGINALD GEORGE, B.A., Taunton's School, Southampton.

1929 TAYLOR, THOMAS CHARLES, B.Sc., Sir George Monoux Grammar School, Walthamstow, E.17; 86, Upperton Road, Plaistow, London, E.13.

1930 TAYLOR, WILLIAM, M.A., B.A. Provincial Training College, Moray House, Edinburgh, 8.

1936 TEMPLE, GEORGE F. J., Ph.D., D.Sc., Professor of Mathematics, University of London, King's College; 8, Hill Close, Hampstead Way, London, N.W.11.

1936 TENNANT, WILFRED, M.A., B.Sc., Dauntsey's School, West Lavington, Nr. Devizes, Wiltshire.

1924 †TERNOUTH, Miss ELSIE JANE, M.A., Lecturer in Mathematics, The University, Reading, Berks.

1915 TESH, Miss GERTRUDE MARY, B.A., The Girls' Grammar School, Batley, Yorks; Nowhere. White Lee, Batley, Yorks.

1931 TESTER, HENRY ERNEST, B.Sc., Ass.M.I.Pet. Tech., 67, Whitton Dene, Isleworth, Middlesex.

1935 THATCHER, ARTHUR MAURICE, B.A., Worksop College, Notts.

1934 THÉBAULT, VICTOR, Ancien Professeur de Mathématiques; 50 Rue de Wagram, Le Mans, France.

1937 THEOPHILUS, S. E., Chief Draughtsman, Sewerage Department, Municipality, Singapore.

1928 THOMAS, JAMES MARTIN, M.A., B.Sc., F.R.G.S., County School, Liskeard; Sunnymead, Station Road, Liskeard, Cornwall.

1924 THOMAS, JOHN, B.A., Upholland Grammar School; Hawthorne House, Moss Road, Orrell, Wigan, Lancs.

1932 THOMAS, Miss MURIEL BLANCHE, B.Sc., Arnold High School for Girls, Blackpool; 358, Lytham Road, Blackpool, Lancs.

1935 THOMAS, RONALD HOWEL, B.Sc., Llanidloes County School, Llanidloes, Mont.

1935 THOMAS, Rev. SAMUEL HENRY, M.A. Epsom College, Epsom, Surrey.

1935 THOMAS, Mrs. TESSIE LOUISE, West Norfolk and King's Lynn High School; Tolma, Gaywood, King's Lynn, Norfolk.

1920 THOMPSON, ALFRED ROSS, M.A., Head Master of Solihull School; The School House, Solihull, Warwickshire.

1931 THOMPSON, Miss ALICE H., B.Sc., Lewisham Prendergast School for Girls, Catford; 9, Eliot Park, Lewisham, London, S.E.13.

1921 THOMPSON, HERBERT JOHN, M.Sc., Elizabeth College, Guernsey, Channel Islands.

1928 THOMPSON, Miss HILDA, B.Sc., Sheffield High School; 78, Clarkegrove Road, Sheffield, 10, Yorks.

1913 †THOMPSON, Mrs. JESSIE FORBES, Ph.D., Kentish Croft, Shootersway, Berkhamsted, Herts.

1937 THOMPSON, JOHN ROBERTON, B.Sc., The College Secondary School, Swindon, Wilts.

1926 THOMPSON, WILFRID JANSEN, M.A., Calday Grange Grammar School, West Kirby, Cheshire; 149, Whitecross Road, Hereford.

1884 †THOMSON, Sir WILLIAM, Kt., M.A., B.Sc., LL.D., formerly Principal of the University of the Witwatersrand, Dunedin, Glencairn, P/o. Simonstown, South Africa.

1935 THOMSON, WILLIAM GRANT, M.A., Robert Gordon's College, Aberdeen; 24, Hammerfield Avenue, Aberdeen.

1920 THORNE, HAROLD HENRY, M.A., B.Sc., F.R.A.S., The University of Sydney, New South Wales, Australia.

1930 THORP, Miss DORA, (Math. Trip.), High School for Girls, Pontefract, Yorks; Tremarth, Charlestown, Ackworth, Yorks.

1936 THORP, JOHN RUSSELL, B.A., Instructor Lieutenant in the Royal Navy; 7, Rosemount, West Byfleet, Surrey.

1934 THUBRUN, Miss NANCY, B.Sc., Central Newcastle High School; 182, Ladykirk Road, Newcastle-upon-Tyne, 4.

1933 TODD, JAMES MACLEAN, M.A., Stowe School, Buckingham.

1935 TODD, JOHN, B.Sc., Department of Mathematics, Queen's University, Belfast; 79, Maryville Park, Malone Road, Belfast, Northern Ireland.

1933 TODHUNTER, VIVIAN ISAAC, M.A., Royal Naval College, Dartmouth; 40, Bush Grove, Stanmore, Middlesex.

1929 TOLL, CLAUDE SELVEY, B.A., Westminster Training College; 6, Green Street, Stevenage, Herts.

1934 TOMKYS, WILLIAM ARTHUR, B.Sc., Belle Vue High School for Boys, Bradford; 158, Haworth Road, Bradford, Yorks.

1908 TOMLINSON, JOHN, M.Sc., B.A., County School, Dover; 102, Crabble Villas, Dover, Kent.

1933 TONGUE, FRANCIS JAMES, B.A., Kingswood School, Bath; Emaney, Van Dieman's Lane, Bath, Somerset.

1930 †TONKIN, Miss LILIAN SARAH, M.A., Howell's School, Llandaff; Tealby, Lincoln.

1937 TOWLE, Miss DOROTHY MARGARET, B.A., Herts and Essex High School, Bishop's Stortford; 26A, Warwick Road, Bishop's Stortford, Herts.

1927 TRANTER, HARRY HAROLD, Municipal Secondary School, Wolverhampton; 78, Clark Road, Wolverhampton, Staffs.

1922 TRAVERS, JAMES, B.A., B.Sc., Head Master of Peterborough College, Harrow; 23, Bouverie Road, West Harrow, Middlesex.

1927 TREDGOLD, Miss JOAN ALISON, M.A., Roedean School, Brighton, Sussex; St. Martin's, Guildford, Surrey.

1935 TREGENZA, CHARLES WILFRID, M.A., 24, Springfield Mount, Leeds, 2, Yorks.

1918 TREHEARNE, Miss MILDRED S., B.A., Talbot Heath School, Bournemouth, Hants; 23, Perryn House, Bromyard Avenue, Acton, London, W.3.

1930 TRICKEY, Miss ELSIE MARY, B.A., Grey Coat Hospital, Westminster; 13, Hookfield, Epsom, Surrey.

1908 TRIST, Lt.-Col. LESLIE HAMILTON, D.S.O., M.C., M.A., Rossall School, Fleetwood, Lancs.

1935 TROMANS, HAROLD, B.Sc., The County Secondary School, Sandown, Isle of Wight.

1935 TROWBRIDGE, WILLIAM HENRY, B.A., Loughborough Grammar School; 66, Beacon Road, Loughborough, Leics.

1932 TRUBRIDGE, GEORGE FRED PARKHURST, M.Sc., Ph.D., F.S.S., University of London Goldsmiths' College; Barylla, Kingsway, Petts Wood, Kent.

1925 TRUDINGER, W. H., 27, Gerald Street, Murrumbeena, Victoria, Australia.

1934 TRUSTRAM, SYDNEY FRANK, B.Sc., Holly Lodge High School for Boys, Smethwick; 15, Marion Road, Smethwick, Staffs.

1936 TUCK, THOMAS SAMUEL POWELL, M.Sc., Penarth County School, Glam.; 22, Zoar Avenue, Maesteg, Glam.

1902 TUCKEY, CHARLES ORPEN, M.A., formerly of Charterhouse; 24, Lonsdale Road, Bournemouth, Hants.

1925 TULLOCH, JOHN SKELDON, A.M.I.Mech.E., A.M.I.Loco.E., Bassein, Upper Coniscliffe Road, Darlington, Co. Durham.

1928 TUPMAN, JOHN BERNARD, M.A., Lowlands, Haines Hill, Taunton, Somerset.

1928 TUPPER, SYDNEY JOHN, B.Sc., Fermoy, Seaview, Isle of Wight.

1926 TURNBULL, HERBERT WESTREN, M.A., F.R.S., Regius Professor of Mathematics at United College, University of St. Andrews; Randa, Hepburn Gardens, St. Andrews, Fife, Scotland.

1936 TURNER, Miss AMY, B.A., Alcott Dairy Farm, Quarmby, Huddersfield, Yorks.

1917 TURNER, Miss WINIFRED MABEL, B.A., Varndean School for Girls, Brighton; 59, Hollingbury Park Avenue, Brighton, 6.

1936 TURTLE, ERIC BAINTON (Commander, R.N., Retd.), Downside School, Woodcote Lane, Purley, Surrey; 102A, Philbeach Gardens, London, S.W.5.

1935 TURTON, ALFRED, M.Sc., Wigan Grammar School; Varazze, 7, Blundell Drive, Birkdale, Southport, Lancs.

1920 TYERS, FREDERICK GEORGE, M.A., Boys' High School, Potchefstroom, Transvaal, South Africa.

1930 TYLER, GEORGE D., B.A., B.Sc., Raine's Secondary School; 5, Empress Avenue, Wanstead Park, London, E.12.

1928 UNDERWOOD, FRANK, M.Sc., Lecturer in Mathematics, University College, Nottingham; Billesdon, 51, Charnock Avenue, Wollaton Park, Nottingham.

1937 UNDERWOOD Miss JOAN MARGARET, B.A., 15, Wood Vale, London, N.10.

1935 UNWIN, Miss GLADYS WINIFRED, M.A., F.R.G.S., Tiffin Girls' School, Kingston-on-Thames; 8, Renters Avenue, Hendon, London, N.W.4.

1923 UNWIN, PERCY CHARLES, M.A., Clifton College; 46, College Road, Clifton, Bristol, 8.

1931 UPPERTON, Miss EVELYN, M.A., Nottingham High School for Girls; 3, Hartington Villas, Hove, Sussex.

1933 †URSELL, HAROLD DOUGLAS, M.A., formerly Fellow of Trinity College, Cambridge; Department of Mathematics, The University, Leeds 2, Yorks.

1935 USHER, JOHN STOCKS WOOD, M.A., H.M.I., 9, The Garth, Kenton Lane, Newcastle-on-Tyne, 3.

1927 VAN DER BYL, FLEMING VOLTELIN. M.A., Ph.D., Litt.D., F.R.Hist.S., F.R.A.S., F.R.Met.S., F.R.G.S., F.R.S.S., F.R.Econ.S., Doct. Univ. Paris, University Lecturer in Trinity College, Dublin.

1901 VAN DER HEYDEN, ALEXANDER FREDERICK, M.A., Middlesbrough High School; formerly Fellow of the University of Durham; 20, Breckon Hill Road, Middlesbrough, Yorks.

1919 VEITCH, Mrs. ELEANOR BEATRICE, M.A. M.Sc., Fellow and Lecturer of Girton College, Cambridge.

1935 VENNING, DONALD LANGFORD, B.A., Forest School, Walthamstow, London, E.17.

1930 VERNEY, Miss DOROTHY, B.Sc., Broughton High School, Salford; 8, Park Road, Monton, Eccles, Manchester.

1929 VESSELO, ISAAC, B.Sc., Stationer's Company's School, Hornsey, N.8; Styvechale, 26, Ventnor Drive, Totteridge, London, N.20.

1930 VIEYRA, Miss MERLE. M.A., B.Sc., Convent of the Sacred Heart High School, Hammersmith; 37, Hornton Street, Campden Hill, London, W.8.

1936 VIGNAUX, Rev. ERNEST, M.A., St. Aloysius' College, Glasgow, C.3.

1920 †VINT, JAMES, M.A., Lecturer in Mathematics in the University of Bristol.

1933 WADDAMS, LESLIE THOMAS, M.A., B.Sc., Barnes, Christ's Hospital, Horsham, Sussex.

1925 WADDELL, Miss WINIFRED, B.Sc., Melbourne Church of England Girls' Grammar School; 6, Albany Road, Toorak, S.E.2, Melbourne, Victoria, Australia.

1926 WADLEY, HAROLD WALTER ATTWOOD, M.A., The Grammar School, Kingston-upon-Thames; The Hill, Kingsmead Avenue, Worcester Park, Surrey.

1892 WAGSTAFF, WILLIAM HENRY, M.A., Professor of Geometry, Gresham College, formerly Head Master of the Central Foundation School, Cowper Street, E.C.2; 17, Aberdeen Park, London, N.5.

1932 WAHLTUCH, Miss MAUD E., M.A. (Mother Mary Cephas, S.H.C.J.), Convent Secondary School, 22, Winckley Square, Preston, Lancs.

1920 WAITE, Miss MARGARET, M.A., Girls' High School, Darlington; 7, Church Street, Durham.

1923 WALKER, ALBERT GEORGE, B.Sc., County Technical and Secondary School, Workington; 12, Derwent Avenue, Seaton, Nr. Workington, Cumberland.

1935 WALKER, ARTHUR, B.A., Royal Grammar School, Worcester.

1932 WALKER, ARTHUR GEOFFREY, M.A., Ph.D., F.R.A.S., University of Liverpool; 55, Whippendell Road, Watford, Herts.

1933 WALKER, EDWIN WILLIAM, B.Sc., County School for Boys, Gravesend; 41, Windmill Street, Gravesend, Kent.

1936 WALKER, PAUL NELSON, M.A.,. B.Com., 44, Selwyn Road, Epsom, Auckland, S.E.3, New Zealand.

1934 WALKER, RAYMOND, M.A., Stowe School, Buckingham.

1933 WALLACE, DAVID MELVILLE, B.Sc., Stranraer High School; 19, Westport Place, Cupar, Fife, Scotland.

1928 WALLACE, Miss NORAH EILEEN, 5, Kensington Park Gardens, London, W.11.

1932 WALLBANK, Miss SARAH ANNIE, B.Sc., Southern Secondary School for Girls, Portsmouth; 12, Worthing Road, Southsea, Hants.

1924 WALLEN, Miss HENRIETTA SYLVIA GERTRUDE, B.Sc., Secondary School for Girls, Worcester; 26, Hanley Road, Shirley, Southampton.

1910 †WALLER, Miss ROSAMUND M., B.A., Head Mistress, Bishop Cotton Girls' School, Bangalore, India.

1931 WALLIS, BERTIE COTTERELL, B.Sc. (Econ.), Wandsworth Technical Institute; 345, Stag Lane, London, N.W.9.

1937 WALLIS, Miss KATHLEEN, B.Sc., Bromley County School for Girls; 28, Winscombe Crescent, Ealing, London, W.5.

1937 WALLIS, PETER JOHN, Pembroke College, Cambridge.

1933 WALTER, Miss MARGARET LUCY, M.A., Collegiate School for Girls, Leicester.

1936 WALTERS, GERALD LLOYD, Headmaster, Upland House, Buchan Hill, Nr. Crawley, Sussex.

1935 WALTERS, GEORGE WILLIAM, B.Sc., Kilburn Grammar School; Penrhos, 136, Harrowdene Road, North Wembley, Middlesex.

1934 WALTON, RAYMOND HENRY, 275, Croxted Road, West Dulwich, London, S.E.21.

1932 WARD, GEORGE WILFRED, M.A., Archbishop Holgate's Grammar School, York; Cotswold, 77, Askham Lane, Acomb, York.

1936 WARMINGTON, Miss MARJORY PATIENCE, B.Sc., Head Mistress, Varndean School for Girls, Brighton; Overbury, Tewkesbury, Glos.

1900 †WARNER, ERNEST THOMAS, M.A., The Chestnuts, Elstead, Surrey.

1930 WARREN, Miss KATHLEEN MARY, B.Sc., County School for Girls, Tonbridge; 108, Pembury Road, Tonbridge, Kent.

1914 WATERS, Miss CHARLOTTE M., B.A., Mole End, Preston Road, Yeovil, Somerset.

1935 WATKINS, CHARLES STANLEY, M.A., Haberdashers' Aske's Hampstead School, London, N.W.2

1937 WATSON, Miss EVA MARGARET, M.A., Sir John Deane's Grammar School, Northwich, Cheshire; Hill Top, Whitegate, Cheshire.

1913 †WATSON, GEORGE NEVILLE, Sc.D., F.R.S., Professor of Mathematics in the University of Birmingham; late Fellow of Trinity College, Cambridge; The University, Edgbaston, Birmingham. (President, 1932–1933.)

1935 WATSON, Miss MARIANNE, B.Sc., The Duchess' School, Alnwick; 16, Bailiffgate, Alnwick, Northumberland.

1936 WATTS, FREDERICK CLEMENT, M.A., Cardiff Technical College; 196, Albany Road, Cardiff.

1911 WEATHERBURN, CHARLES ERNEST, M.A., D.Sc., Professor of Mathematics in the University of Western Australia, Crawley, Perth, Western Australia.

1934 WEBB, ERNEST WILLIAM, M.Sc., Godalming County School, Hazel Bank, Busbridge Lane, Godalming, Surrey.

1924 WEBBER, ALAN CLOSE, A.R.C.S., Aldenham School, Elstree, Herts.

1913 WEDDERBURN, Professor JOSEPH HENRY MACLAGAN, D.Sc., F.R.S., Princeton University; Box 53, Princeton, New Jersey, U.S.A.

1935 WEEKS, GEORGE ALBERT B.Sc., Dulwich Central School; 34, Chessington Way, West Wickham, Kent.

1933 WEICH, SHLOMO, Hebrew Secondary School, Haifa, Hadar-Hakarmel, Palestine.

1912 †WEIGHELL, Miss GLADYS MARY, B.A., Head Mistress of Cathays High School, New Zealand Road, Cardiff, Glam.

1914 †WELCH, JAMES JOHNSON, M.A., 3, Rose Crescent, Cambridge; Baldock Road, Royston, Herts.

1935 WELFORD, PETER GEORGE, B.A., Moseley Secondary School, Birmingham, 13; 61, Peacock Road, King's Heath, Birmingham, 14.

1916 †WELLISH, EDWARD MONTAGUE, M.A., B.A., Associate Professor of Applied Mathematics in the University of Sydney, New South Wales, Australia.

1908 WENHAM, Miss HILDA, B.A., 7, Queen's Mansions, Brook Green, London, W.6.

1937 WEST, ALFRED ERNEST JASPER, B.A., B.Sc., Fernlea, 13, Freelands Road, Cobham, Surrey.

1935 WEST, WILLIAM JAMES, B.Sc., Secondary School, Dursley; 1, Woodland Avenue, Dursley, Glos.

1917 WESTBURY, Miss GLADYS ETHEL, B.Sc., Putney High School; 40, Park Road, Chiswick, London, W.4.

1903 WESTCOTT, GEORGE JOHN BILES, M.A., 20, Linden Road, Redland, Bristol.

1898 WESTERN, ALFRED EDWARD, Sc.D., 44, Lansdowne Crescent, Notting Hill, London, W.11.

1927 WESTMORELAND-WHITE, Mrs BERTHA, B.Sc., The Elliott Central School for Girls, Merton Road, S.W.18; 99, Norfolk Avenue, Sanderstead Surrey.

1934 WHEELER, HARRY ARNOLD, M.Sc., Gateshead Secondary School; Weardale, Lyndhurst Grove, Low Fell, Gateshead, Co. Durham.

1905 WHIPPLE, FRANCIS JOHN WELSH, M.A., Sc.D., F.Inst.P., Superintendent of Kew Observatory; 6, Addison Road, Chiswick, London, W.4.

1935 WHITAKER, Miss GERTRUDE LUCY, B.Sc., Head Mistress of the High School for Girls, Ribston Hall, Gloucester.

1921 WHITE, FRANCIS PURYER, M.A., B.Sc., University Lecturer in Mathematics; Fellow and Lecturer in St. John's College, Cambridge.

1927 WHITE, Mrs. JESSIE, D.Sc., B.A. (Moral Sc. Trip.), Auto-Education Institute, 46, Great Russell Street, London, W.C.1.

1920 WHITE, JOHN BANWELL, M.A., Head Master of Queen Elizabeth's Hospital, Bristol.

1936 WHITE, Miss MARION, B.Sc., Washington Secondary School, Co. Durham; One Ash, West Lane, Chester-le-Street, Co. Durham.

1935 WHITE, TERENCE WILLIAM, B.A., Ampleforth College, York.

1931 WHITEHEAD, PERCY, M.A., City of Norwich School; 61, Park Lane, Norwich.

1933 WHITEHEAD, ROBERT, M.A., Colston's School, Stapleton, Bristol.

1920 WHITELEY, FREEMAN PEARSON, M.A., Head Master, Waverley Secondary School, Small Heath, Birmingham, 10; 26, Salisbury Road, Moseley, Birmingham, 13.

1935 WHITING, Miss MADELINE HOLLAND, M.A., Wimbledon High School, South Corner, Belmont, Sutton, Surrey.

1932 WHITROW, GERALD JAMES, B.A., 37, Cedars Row, Clapham Common, London, S.W.4.

1935 WHITTAKER, HARRY A., M.A., F.R.A.S., King Edward VI School, Nuneaton, Warwickshire; 32, Turnpike Street, Elland, West Yorks.

1934 WHITTLE, Miss NORAH MARGUERITE, Altrincham County High School for Girls; 55, Acacia Avenue, Hale, Altrincham, Cheshire.

1935 WHITTLESTONE, HAROLD, B.Sc., The Grammar School, Normanton; 16, Milnthorpe Crescent, Sandal, Wakefield, Yorks.

1925 WICKENS, CHARLES HENRY, I.S.O., F.I.A., F.S.A., 3, Angle Road, Balwyn, E.8, Victoria, Australia.

1920 WICKS, ALBERT TOM, M.A., Monckton Combe School, Bath, Somerset.

1932 WILD, MAURICE DARWIN, B.Sc., Birkenhead Institute, Whetsone Lane, Birkenhead, Cheshire.

1907 WILES, CLEMENT CHRISTOPHER, M.A., Head Master of the Victoria Boys' High School, Grahamstown, South Africa.

1920 WILKES, Miss LUCY, M.A., St. Mary's College, Bangor; 112, Lordswood Road, Harborne, Birmingham.

1922 WILKINSON, GEORGE WILLIAM, M.Sc., Nether Edge Secondary School, Sheffield; 77, Banner Cross Road, Ecclesall, Sheffield, 11, Yorks.

1908 †WILKINSON, Mrs. LILIAN ELIZABETH, B.A., M.A., 5, Queen's Mansions, King George Street, Johannesburg, South Africa.

1928 WILKS, WILLIAM JOSEPH, c/o Messrs. Bryant & May, Ltd., Fairfield Works, Bow, London, E.3.

1931 WILLÉ, JOHN EDWARD, M.A., B.Sc., St. Albans School, Herts; 53, Holywell Hill, St. Albans, Herts.

1929 WILLIAMS, ALFRED CECIL, M.A., B.A.I., Inspector of Mathematics, Ministry of Education, Northern Ireland; Delgany, 60, Knockloity Park, Belfast, Northern Ireland.

1930 WILLIAMS, Miss ANNIE, B.Sc., County School for Girls, Porth; 10, The Parade, Porth, Glam.

1925 WILLIAMS, Miss BESSIE, B.A., County School, Milford Haven; 155, Rhyddings Terrace, Swansea, Glam.

1935 WILLIAMS, Miss DORA, B.A., The County High School, Moat Road, Langley, Nr. Birmingham.

1933 WILLIAMS, EDWIN MORRIS, B.Sc., Bryanston School, Blandford, Dorset.

1932 WILLIAMS, Mrs. EMILY MAY, B.A., Lecturer in Education, Goldsmiths' College, University of London; Brandon House, 22, Warwick Road, New Barnet, Herts.

1918 WILLIAMS, JOSEPH THOMAS, M.Sc., A.Inst.P., The Homestead, Caerwent, Nr. Chepstow, Mon.

1936 WILLIAMS, Miss MARJORIE L., B.A., Brondesbury and Kilburn High School; 56, Salterford Road, Tooting, London, S.W.17.

1935 WILLIAMS, SAMUEL EWART, B.Sc., Head Master of the Intermediate School, Mill Street, Brierley Hill, Staffs.

1924 WILLIAMSON, Miss ALICE FRANCES ADA, B.A., Merchant Taylors' Girls' School, Great Crosby; 16, Ilford Avenue, Great Crosby, Liverpool, 23.

1936 WILLIAMSON, ERNEST FREDERICK, B.Sc., County High School, Braintree; Drummore, High Garret Road, Braintree, Essex.

1919 WILLIAMSON, RALPH STANLEY, M.A., Vice-Principal and Lecturer, Cambridge University Training College for Schoolmasters; Stanmore, 3, Luard Road, Cambridge.

1924 WILLIS, ALEXANDER GALBRAITH FLEMING, M.A., Head Master of Surbiton County School, Surbiton Hill, Surrey.

1924 WILLIS, Miss MAY, M.A., Cowley Girls' School, St. Helens; Windle Cottage, Bishop Road, St. Helens, Lancs.

1928 WILLIS, REGINALD WILLIAM, M.Sc., St. Marylebone Grammar School; Dell View, Bercean Walk, Watford, Herts.

1935 WILLIS, ROBERT WILLIAM GASPARD, M.A., Malvern College; Kinmore, Manby Road, Malvern, Worcs.

1935 WILLIS, SANDHAM JOHN, M.A., Ph.D., College of S. Columba, Rathfarnham, Co. Dublin, Irish Free State.

1922 WILMOTT, Miss JESSIE MAUD, B.Sc., Cavendish High School, Buxton; Greenways, Spencer Grove, Buxton, Derbyshire.

1920 WILSON, ALFRED KENNETH, M.A., Head Master of Dame Allan's School, Newcastle-upon-Tyne; 22, Framlington Place, Newcastle-upon-Tyne.

1919 WILSON, Miss DAISY, M.A., Barr's Hill School, Radford Road, Coventry, Warwickshire.

1935 WILSON, Miss GLADYS MARY, B.Sc., High School for Girls, Douglas; 25, Victoria Crescent, Douglas, Isle of Man.

1937 WILSON, Miss JOYCE, B.Sc., Girls' High School, Lindum Road, Lincoln.

1935 WILSON, Miss JOYCE ELIZABETH, B.Sc., Colston's Girls' School, Bristol; 24, Hill Crescent, Totteridge, London, N.20.

1914 †WILTON, JOHN RAYMOND, M.A., D.Sc., Sc.D., Elder Professor of Mathematics in the University of Adelaide, Adelaide, South Australia.

1925 WINCHESTER, Miss JOSEPHINE, B.A., Lady Margaret School, Parsons Green, S.W.6; 70, Sutherland Grove, Southfields, London, S.W.18.

1918 †WISE, Miss ENID, M.A., Head Mistress of the Girls' High School, Skipton-in-Craven; Dunluce, Skipton-in-Craven, Yorks.

1930 †WISEMAN, CHRISTOPHER LUKE, M.A., Queen's College, Taunton, Somerset.

1922 WISHART, JOHN, M.A., D.Sc., F.R.S.E., Reader in Statistics, University of Cambridge; Croft Lodge, Barton Road, Cambridge.

1927 WITHRINGTON, JOHN WILFRED, M.A., M.Sc., Addey and Stanhope School, New Cross, London, S.E.14; Crook Log, Elm Grove, Orpington, Kent.

1933 WOOD, Miss DOROTHY, B.Sc., Milton Mount College, Crawley, Sussex.

1933 WOOD, Miss ELSIE, B.Sc., Barrow-in-Furness Grammar School for Girls; 66, Cheltenham Street, Barrow-in-Furness, Lancs.

1920 WOOD, EVELYN LLOYD, L.C.P., The Hulme Grammar School, Manchester; 8, Grove Terrace, Withington, Manchester.

1933 WOOD, FREDERIC JAMES, B.A., Phillips Exeter Academy, Exeter, New Hampshire, U.S.A.; Wheelwright Hall, Exeter, N.H., U.S.A.

1931 WOOD, JOHN FRANCIS, M.Sc., King's College, University of Durham; Skara Brae, Tynedale Gardens, Stocksfield, Northumberland.

1914 WOOD, LESLIE WILLIAM, B.A., Hillcrest, Great Missenden, Bucks.

1937 WOOD, Miss MARY KATHLEEN, B.Sc., Gainsborough High High School; 8, Love Lane, Gainsborough, Lincs.

1936 WOOD, PHILIP WORSLEY, M.A., Emmanuel College, Cambridge; 1, St. Paul's Road, Cambridge.

1922 †WOODALL, HERBERT JOSEPH, A.R.C.Sc., 261, Adswood Road, Stockport, Cheshire.

1926 WOODCOCK, ALFRED JOHN ANDREW, B.Sc., M.Sc., F.E.S., Medway Technical College, Gillingham; Rhianva, 65, Rock Avenue, Gillingham, Kent.

1934 WOODS, Miss MILLICENT FAIRHURST, M.Sc., Putney County Secondary School; Leghville, Golborne, Nr. Warrington, Lancs.

1929 WOOLNER-BIRD, WILLIAM FLINDELL, M.A., 21, Sunnyside, Epping, Essex.

1922 WOOTTON, DAVID, B.Sc., Weymouth Grammar School; Rydal Lodge, Radipole, Weymouth, Dorset.

1937 WORK, Miss JANET P., M.A., Orme Girls' School, Newcastle, Staffs.

1934 WORTHINGTON, ARTHUR AGNEW, B.Sc., The County School, Camberley; Fairmuir, Frimley Road, Camberley, Surrey.

1935 WORTHINGTON, EDWARD, M.A., George Dixon Secondary School, Birmingham; 43, Willow Avenue, Edgbaston, Birmingham, 17.

1935 WOTHERSPOON, GEORGE, M.A., formerly Vice-Master, King's College School, Wimbledon; 54, Coleherne Court, London, S.W.5.

1933 WREN, JOHN CHARLES EDWARD, M.A., B.Sc., The Grammar School, Burnley, Lancs.

1923 WRIGHT, Miss ANNIE JANE, F.R.G.S., Dover Road Girls' School, Folkestone; 22, St. John's Street, Folkestone, Kent.

1930 WRIGHT, GEORGE HOWARD, B.Sc., Tottenham County School; 30, Blakesware Gardens, London, N.9.

1916 WRIGHT, Miss HILDA MARION, M.A., Head Mistress of Guildford County School for Girls; Sutton Lodge, Clandon Road, Guildford, Surrey.

1913 †WRIGHT, REGINALD MONTAGUE, M.C., M.A., Second Master of Winchester College; The College, Winchester, Hants.

1919 WRINCH, Miss DOROTHY MAUD, D.Sc., M.A., Mathematical Tutor to Women Students, Oxford; Lady Margaret Hall, Oxford.

1918 YELDHAM, Miss FLORENCE ANNIE, B.Sc., Ph.D., Tralee, 54, Wilmot Way, Banstead, Surrey.

1924 YONGE, Miss DOROTHY, M.A., Head Mistress, Day Technical School, Fort Pitt, Chatham, Kent.

1933 YORKE, GILBERT, B.Sc., Ross-on-Wye Grammar School; Vernon Bank, Chase Road, Ross-on-Wye, Herefordshire.

1923 YORKE, SYDNEY VICTOR, B.Sc., St. Olave's School, Tower Bridge, London, S.E.1; 41, Taymount Grange, Queens Road, Forest Hill, S.E.23.

1927 YOUNG, BERNARD, B.Sc., Grammar School, Leigh, Lancs; 34, Folly Lane, Swinton, Manchester.

1926 YOUNG, DOUGLAS ALAN, B.A., Principal of St. Clement's School, Sutton-on-Sea, Alford, Lincs.

1935 YOUNG, Miss EDITH ISABELLA, M.A., B.Sc., 32, Queen's Gate, Glasgow, W.2.

1934 YOUNG, SYDNEY GEORGE, B.Sc., Cathays High School, Cardiff; Davington, Heol Wen, Rhiwbina, Cardiff, Glam.

1898 †YOUNGMAN, CHARLES ELLIS, M.A., Charsfield, Woodbridge, Suffolk.

1904 ZAIR, JOHN ARTHUR, M.A., The Knoll Preparatory School; The Knoll, Woburn Sands, Bletchley, Bucks.

Libraries, Schools, etc.

1937 ALDENHAM SCHOOL, Elstree, Herts. (The Librarian.)

1931 ANNAMALAI UNIVERSITY, Annamalainagar, South India. (The Librarian.)

1936 BROWN UNIVERSITY LIBRARY, Providence, Rhode Island, U.S.A. (The Librarian.)

1923 CAMBRIDGE UNIVERSITY COLLEGE FOR SCHOOLMASTERS, 17, Brookside, Cambridge. (The Secretary.)

1925 CANTERBURY UNIVERSITY COLLEGE, Christchurch, New Zealand. (The Librarian.)

1936 CARDIFF TECHNICAL COLLEGE (Mathematics Department). (The Librarian.)

1910 FISHER LIBRARY, University of Sydney, Sydney, New South Wales, Australia. (The Librarian.)

1931 GREY UNIVERSITY COLLEGE, Bloemfontein, Union of South Africa. (The Librarian.)

1937 HARROW SCHOOL MATHEMATICAL LIBRARY, Harrow-on-the-Hill, Middlesex. (The Librarian.)

1929 JOHANNESBURG PUBLIC LIBRARY, Library Buildings, Kerk Street, Johannesburg, Transvaal, South Africa. (The Librarian.)

1935 MARLBOROUGH COLLEGE MATHEMATICAL LIBRARY, The College, Marlborough, Wilts. (The Librarian.)

1934 MUIR MATHEMATICAL LIBRARY, South African Public Library, Cape Town, South Africa. (The Librarian.)

1935 TEACHERS' COLLEGE, University Grounds, Newtown, Sydney, New South Wales, Australia. (The Librarian.)

1930 TIFFIN BOYS' SCHOOL, Kingston-on-Thames, Surrey. (The Headmaster.)

1918 UNIVERSITY COLLEGE, CORK, Ireland. (The Librarian.)

1930 UNIVERSITY COLLEGE, DUNDEE, Angus, Scotland. (The Librarian.)

1930 UNIVERSITY COLLEGE OF NORTH WALES, Bangor, North Wales. (The Librarian.)

1927 UNIVERSITY LIBRARY, READING, Berks. (The Librarian.)

1913 UNIVERSITY OF SHEFFIELD, Sheffield, Yorks. (The Librarian.)

1915 UNIVERSITY OF TEXAS, Austin, Texas, U.S.A. (The Librarian.)

1926 UNIVERSITY OF THE WITWATERSRAND, Johannesburg, Transvaal, South Africa. (The Librarian.)

1935 WELLS HOUSE SCHOOL, Malvern Wells, Worcs. (The Mathematical Master.)

1932 WILSON COLLEGE, Bombay, India. (The Principal.)

Index of Members according to Schools.

ENGLAND.

BEDFORDSHIRE.

Bedford High School.—Batley, Miss E. M.; Cracknell, Miss E. E.; Sanders, Miss E. M.

Bedford School.—Renwick, J. E.

Luton High School for Girls.—Dowdall, Miss C. A.

Luton Modern School.—Godfrey, C. J.

BERKSHIRE.

Abingdon: Radley College.—Fanshawe, N. H.

Bracknell: Ranelagh School.—Strawson, G. E.

Eton College.—Bousfield, D. G.; Chute, Rev. J. C.; Hope-Jones, W.; MacKinnon, P. V.; Marsden, H. K.; Smyth, T. H.

Maidenhead County Girls' School.—Bridger, Miss E. A.

Newbury: The Girls' School.—Mackenzie, Miss K. I

Reading: Kendrick Girls' School.—Cook, Miss E.; Prebble, Miss D.

Reading: Leighton Park School.—Moore, R. D. L.

Reading University.—Neville, Prof. E. H.; Ternouth, Miss E. J.

Sonning: Farnborough School.—Collinson, J.

Wellington College.—Buckley, A.; Roseveare, R. V. H.

Windsor County Boys' School.—Blow, C.; Bransden, B. W. D.

BUCKINGHAMSHIRE.

Aylesbury Grammar School.—Murray, Miss H. C.

Bletchley: Swanbourne House.—Roebuck, F. A.

Buckingham: Royal Latin School.—Allitt, T. R.

Buckingham: Stowe School.—Archer, A. G.; Todd, J. M.; Walker, R.

Chesham: Whitehill Senior Girls' School.—Edwards, Miss F. J. H.

High Wycombe: Royal Grammar School.—Clark, W.

High Wycombe: Wycombe Abbey.—Darling, Miss M. R.

High Wycombe: Wycombe High School.—Blacker, W. E. B.; Dawson, Miss S. E.

Slough Grammar School.—Smith, E. P. C.

Slough High School for Girls.—Cooke, Miss W. A.

Woburn Sands: The Knoll Preparatory School.—Zair, I. A.

CAMBRIDGESHIRE.

Cambridge: Cambridgeshire Technical School.—Rose, G. F.

Cambridge: Clare College.—Wishart, Dr. J.

Cambridge and County High School for Boys.—Boyle, G. L.; Marsden, T.; Mayne, A. B.

CAMBRIDGESHIRE—Contd.

Cambridge and County High School for Girls.—Barnett, Miss P. M.; McKelvie, Miss M.

Cambridge: Emmanuel College.—Wood, P. W.

Cambridge: Girton College.—Cartwright, Dr. M. L.; Veitch, Miss E. B.

Cambridge: Homerton College.—Carless, Miss F. D.

Cambridge: King's College.—Richmond, H. W.

Cambridge: Magdalene College.—Ramsey, A. S.

Cambridge: Newnham College.—Grimshaw, Miss M. E.

Cambridge: Perse Girls' School.—Birks, Miss E. W.; Murray, Miss D. E. G.

Cambridge: St. John's College.—Larmor, Prof. Sir Joseph; White, F. P.

Cambridge: Perse School.—Braithwaite, G.; Buchanan, J.

Cambridge: Peterhouse.—Burkill, J. C.

Cambridge: Queens' College.—Maxwell, Dr. E. A.

Cambridge: St. Faith's School.—Hull, L. W. H.

Cambridge Training College for Women.—Taylor, Miss M. B.

Cambridge: Trinity College.—Dean, W. R.

Cambridge University.—Eddington, Sir, A. S.; Hardy, Prof. G. H.

Cambridge University Training College for Schoolmasters.—Williamson, R. S.

CHESHIRE.

Altrincham: County High School for Girls.—Whittle, Miss N. M.

Birkenhead High School.—Leighton, Miss L. M.

Birkenhead Institute.—Wild, M. D.

Birkenhead School.—Bushell, W. F.; Poole, A. W.

Chester: City and County School for Girls.—Roper, Miss G. M.

Chester: The Queen's School.—King, Miss D. L.; Nedham, Miss M. T.

Hoylake: Leas Preparatory School.—Barr, C. J. H.

Macclesfield Grammar School.—Shaw, T. T.; Garreau, G. A.

Nantwich and Acton Grammar School.—Caunt, P. B.

Northwich: Sir John Deane's Grammar School.—Watson, Miss E. M.

Rock Ferry High School.—Parkinson, W. G.

Runcorn County Secondary School.—Jackson, T. H.

Stockport High School.—Lloyd, Miss D. M.

Wallasey: Oldershaw School for Boys.—Atherton, R. R.

Wallasey Grammar School.—Baldwin, R.

West Kirby: Calday Grange Grammar School.—Thompson, W. J.

West Kirby: County High School for Girls.—Sanderson, Miss M.

Winsford: Verdin Grammar School.—Russell, E.

Wirral County School for Girls.—Hall, Miss B.; Spencer, Miss M. L.

Wirral Grammar School.—Horn, R. B.

CORNWALL.

Camborne County School for Girls.—Evans, Miss H. L. S.

Launceston: Pendruccombe.—Caird, Miss E. M.

Liskeard County School.—Thomas, J. M.

Penzance County School for Girls.—Greenwood, Miss H.

Truro: The Training College.—Rogers, Miss M. M.

CUMBERLAND.

Carlisle: Margaret Sewell Central School.—Dogherty, Miss W.
Penrith: Queen Elizabeth Grammar School.—Jones, R. W.
St. Bees School.—Aston, S. T.
Workington: County Secondary School and Technical College.—Gosling, H. W.; Payne, F. W.; Walker, A. G.

DERBYSHIRE.

Ashbourne: Queen Elizabeth Grammar School.—Mears, H. J.
Belper: The Herbert Strutt School.—Marsh R. J.
Buxton: Cavendish High School.—Wilmott, Miss J. M.
Buxton College.—Clarke, J.
Chesterfield: Brampton Junior Mixed School.—Jolliffe, A. C.
Chesterfield Girls' High School.—Brown, Miss D.; Meetham, Miss M. J.
Chesterfield Grammar School.—Durant, B.; Hodgson, H. B.; Kemp, C. E.; Slack, E. H.
Chesterfield: Netherthorpe Grammar School.—Barwell, C. R.
Derby: Bemrose School.—Critchlow, J.
Derby Central School for Girls.—Pakeman, Miss W.
Derby: Parkfields Cedars Secondary School.—Brind, Miss E. M.; Payne, Miss K. E.
Derby School.—Glister, W. E.
Derby Technical College.—Avery, A. J. L.
Long Eaton County Secondary School.—MacDonald, R.
New Mills County Secondary School.—Macdonald, W. K.
Normanton Grammar School.—Whittlestone, H.
Normanton High School.—Reeve, Miss K.
Repton School.—Clarke, H. G. M.; Ferguson, D. F.; Lyness, R. C.; Milford, M.; Strickland, Lt.-Col. N.

DEVON.

Bideford Grammar School.—Langford, W. J.
Crediton High School.—Prebble, Miss E. J.
Crediton: Queen Elizabeth's School.—Clarke, F.
Dartmouth: Royal Naval College.—Piggott, H. E.; Prout, H. K.; Todhunter, V. I.
Devonport: H.M. Dockyard School.—Chubb, B. J.; Naylor, V.
Devonport Secondary School for Girls.—Everitt, Miss J.; Side, Miss G. A.
Devonport: Stoke Damerel Secondary School for Girls.—Joslin, Miss H. H.; Stimson, Dr. M.
Exeter: Maynard School.—Sutcliffe, Miss E. W.
Exeter School.—Labey, J. E. G.
Exeter: University College.—Brown, T. A.; Mallison, H. V.
Exmouth Grammar School.—Civil, D. E.
Kingsbridge Grammar School.—Lisle, F. B.
Plymouth College.—Bonsor, G. H.
Plymouth Corporation Grammar School.—Sandon, F.
Plymouth High School for Girls.—Davies, Miss M.

DEVON—Contd.
Plymouth: Regent Street Intermediate Girls' School.—Hart, Miss D.
Plymouth: Sutton Secondary School.—Perkins, L. C.
Teignmouth Grammar School.—Bossom, L.; Stroud, L. J.
Tiverton: Blundell's School.—Barton, A.; Batterbee, H. H.
Torquay Grammar School.—Harmer, J. W.
Torquay Grammar School for Girls.—Grundy, Miss N. M.
Totnes County School for Girls.—Mander, Miss F.
Totnes: King Edward VI Grammar School.—Foster, L.; Owen, C. D. T.

DORSET.

Blandford: Bryanston School.—Williams, E. M.
Blandford Grammar School.—Beach, G. L.; Stott, J.
Dorchester County School for Girls.—Fisher, Miss E. A.
Gillingham Grammar School.—Barfield, L. H.
Parkstone: Sandecotes.—Dunn, Miss M.
Shaftesbury Grammar School.—Cave, A. R.
Sherborne School.—Elderton, M. B.; Eperson, Rev. D. B.
Sherborne School For Girls.—Heywood, Miss R. M.
Swanage Grammar School.—Jones, H. N.
Weymouth Grammar School.—Wootton, D.

DURHAM.

Barnard Castle School.—Adlard, M.
Bishop Auckland Grammar School.—Kershaw, E.
Darlington Girls' High School.—Waite, Miss M.
Darlington Grammar School.—Bowley, E. G.; Newton, R. E.
Darlington Training College.—Hardy, Miss H.
Durham Girls' County School.—Gibson, Miss A. E.
Durham: Johnston School.—Appleby, R. E.
Durham University.—Baxter, E. F.; Burchnall, J. L.; Heawood, Prof. P. J.
Gateshead Secondary School.—Hamill, C.; Wheeler, H. A.
Hartlepool: Henry Smith School.—Fothergill, G. H.; Moor, J.
Jarrow County Secondary School.—Keegan, J.
Ryhope Secondary School.—Osborne, C. J.
South Shields High School for Boys.—Brooks, J. W.
South Shields High School for Girls.—Ditchburn, Miss M.; Earp, Miss O. M.
Sunderland: Bede Collegiate Girls School.—Frankenburg, Miss L.
Sunderland High School.—Ormandy, Miss N. L.
Sunderland: Langham Tower Training College.—Smith, J.
Thornaby-on-Tees: Robert Atkinson Central School.—Parratt, L. R.
Washington County Secondary School for Boys.—Leathard, J. W.
Washington County Secondary School for Girls.—White, Miss M.
West Hartlepool: High School for Girls.—Atack, Miss M.
West Stanley: Alderman Wood Secondary School.—Elliott, G. A.
Wingate: A. J. Dawson Secondary School.—Martindale, A.
Wolsingham Grammar School.—Morley, P.

ESSEX.

Barking Abbey School.—Phillips, E.
Barking: Park Modern School.—Jameson, F. N.
Bradfield College.—Sopwith, A.
Braintree County High School.—Williamson, E. F.
Brentwood School.—Deane, H. J.; Everington, G. F.; Miller, H. H. F.
Chigwell School.—Doouss, F. J.
Clacton-on-Sea County High School.—Butler, J.
Colchester County High School for Boys.—King, R. H.
Colchester County High School for Girls.—Cone, Miss Z.; Peatfield, Miss I. L.
Colchester: St. Mary's School.—Butterworth, Miss E.
Dagenham: Erkenwold Boys' School.—Crocker, A. J. St. C.
Dagenham: South East Essex Technical College.—Peat, H.
Dovercourt: Harwich County High School.—Meacock, G. H.
Earls Colne Grammar School.—Knight, D.
Felsted School.—Lockwood, E. H.
Grays: Palmer's School for Boys.—Cramp, A. C.
Grays: Palmer's School for Girls.—Brown, Miss E. T.
Ilford County High School for Boys.—Munro, N.; Rigby, W. J.
Ilford County High School for Girls.—Caiger, Miss J. E.
Loughton County High School for Girls.—Martin, Miss H. M.
Romford: Intermediate School.—Berry, E. H.
Saffron Walden Friends' School.—Pittwood, G. E.
Southend-on-Sea High School for Girls.—Giles, Miss E. M.
Westcliff High School for Girls.—Hughes, Miss A. E. M.
Westcliff-on-Sea Boys' High School.—Smith, H. S.
Woodford County High School.—Appleby, Miss E.

GLOUCESTERSHIRE.

Bristol: Clifton College.—Beaven, H. C.; Lewis, E. P.; Unwin, P. C.
Bristol: Clifton High School.—Biden, Miss M. E.; Garnett, Miss C. O.
Bristol: Colston's Boys' School, Stapleton.—Whitehead, R.
Bristol: Colston's Girls' School.—Gillard, Miss M. M.; Wilson, Miss J. E.
Bristol: Fairfield Secondary School.—Chudleigh, Miss H. F.
Bristol Grammar School.—Lester, G. H.
Bristol: Merrywood Secondary School.—Lyon, M. S.
Bristol: Queen Elizabeth's Hospital.—White, J. B.
Bristol: St. George Secondary School.—Baldwin, Dr. O. R.; Morton, A.
Bristol University.—Fraser, P.; Hassé, Prof. H. R.; Vint, J.
Cheltenham College.—Bond, J. S.; Fletcher, P.; Morris, R. W.
Cheltenham Ladies' College.—Coley, Miss W. M.; Howden, Miss J. E.; Shaw, Miss M.
Cheltenham: Pate's Grammar School for Girls.—Harrison, Miss M. W.
Cirencester Grammar School.—Holgate, Miss G. A.
Cirencester: Rendcomb College.—Richards, A. G. G.
Dursley Secondary School.—West, W. J.
Gloucester Crypt School.—Fletcher, J. K.; Smith, A. L. C.
Gloucester High School for Girls.—Durston, Miss B.; Whitaker, Miss L.

GLOUCESTERSHIRE—Contd.
Gloucester: The King's School.—Loveridge, N. J.
Gloucester: Sir Thomas Rich's School.—Sinkinson, A. T.
Stroud High School.—Rasmussen, Miss M. L.
Tetbury: Westonbirt.—Lauriston, Miss J.

HAMPSHIRE.

Alton: Eggar's Grammar School.—Holford, E. W.
Bembridge School, I.O.W.—Lloyd, R. G.
Bournemouth School.—Clements, R. H.
Bournemouth School for Girls.—Boorn, Miss D. E.
Bournemouth: Talbot Heath.—Trehearne, M. S.
Brockenhurst County High School.—Cockrill, G. W.
Eastleigh County High School.—Stone, R. H.
Fareham: Stubbington House.—Gilmour, W. A.
Petersfield: Bedales School.—Gimson, B. L.; Hollister, Mrs. E.
Portsmouth: Northern Secondary School for Boys.—Celia, C. W.
Portsmouth: Northern Secondary School for Girls.—Payne, Miss I.; Payne, Miss, M. F.
Portsmouth: Southern Secondary School for Boys.—Stephenson, G. H. B.
Portsmouth: Southern Secondary School for Girls.—Wallbank, Miss S. A.
Sandown, I.O.W.: County Secondary School.—Moore, H. N. R.; Tromans, H.
Shanklin I.O.W.: Upper Chine.—Bradbury, Miss D.
Southampton: Atherley School.—Hall, Miss E. E.
Southampton Grammar School for Girls.—Bromby, Miss H.
Southampton: Taunton's School.—Jones, R.; Taylor, R. G.
Southsea: St. Helen's College.—Hawes, C. G.
Southsea: Southern Secondary School.—Davies, S. G.
Winchester College.—Alexander, C. H. O'D.; Browne, W. L. F.; Durrell, C. V.; Hunter, C. B. G.; Wright, R. M.
Winchester: Peter Symonds' School.—Cozens, C. J.
Winchester: St. Swithun's School.—Allen, Miss D. B.; Clark, Miss D. M.; Collett, Miss H. M.

HEREFORDSHIRE.

Bromyard: Queen Elizabeth's Grammar School.—Faulkner, Miss E. G.
Hereford Cathedral School.—Morgan, J. B.
Hereford High School for Boys.—Ruscoe, R. G.
Hereford High School for Girls.—Greaves, Miss M. H.; Stokes, Miss E. H.
Hereford Training College.—Prior, Miss T.
Leominster Grammar School.—Randall, V.
Ross-on-Wye Grammar School.—Yorke, G.

HERTFORDSHIRE.

Barnet: Queen Elizabeth's Grammar School.—Randall, G. F.
Barnet: Queen Elizabeth's Grammar School for Girls.—Facon, Miss E. M.
Berkhamsted School.—Jones, L. A. W.; Smith, S. L.
Bishop's Stortford: Chantry Mount School.—Harries, Miss N.
Bishop's Stortford College.—Sutton, F. S.
Bishop's Stortford: Herts and Essex High School.—Potter, Miss L.; Towle, Miss D. M.

HERTFORDSHIRE—Contd.

Bushey: Royal Masonic (Senior) School.—Mason, E. D.
Bushey: St. Margaret's School.—Lace, Miss O. J.
Elstree: Aldenham School.—Jones, L. E.; Webber, A. C.
Finchley: Christ's College.—Ross, C.
Harpenden: St. George's School.—Hardingham, C. H.
Hemel Hempsted Grammar School.—Screeton, N. H.
Hemel Hempsted Grammar School for Girls.—Newman, Miss F. E.
Hertford: Christ's Hospital.—Mitchell, Miss I. L.
Hertford Grammar School.—Moxon, Capt. R. J.
Hertford: Haileybury College.—Adams, C. W.
Hitchin Girls' Grammar School.—Clark, Miss E. G.
Hitchin: Wellbury Preparatory School.—Kenworthy-Browne, B. E.
Rickmansworth: Masonic School.—Buckley, Miss M. L.
St. Albans School.—Scholield, H.; Willé, J. E.
Watford Boys' Grammar School.—Imeson, K. R.
Watford Central School.—Rice, Miss W. A.
Watford Girls' Grammar School.—Burnley, Miss S.

HUNTINGDONSHIRE.

Fletton Secondary School.—Legg, J. W.
Kimbolton Grammar School.—Gibbard, C. A. H.

KENT.

Ashford High School.—Brown, Miss A.
Beckenham: Balgowan Central School.—Faires, W. G.
Beckenham County School for Boys.—Freeman, M. H.
Beckenham County School for Girls.—Coote, Miss A. M.
Bromley County School for Boys.—Richardson, G.
Bromley County School for Girls.—Rusbridge, Miss E. M.; Wallis, Miss K.
Bromley High School.—Lord, Miss E. E.
Canterbury: King's School.—Harris, J. B.; Paynter, J. R. F.
Canterbury: St. Edmund's School.—Reade, J. A. D.
Canterbury: Simon Langton School.—Hall, P. L.
Canterbury: Sturry Central School.—Gaskell, W.
Chatham County School for Girls.—Strachan, Miss A. M.
Chatham: Day Technical School, Fort Pitt.—Yonge, Miss D.
Cranbrook: Benenden School.—Richards, Miss M. W.
Dover County School for Boys.—Tomlinson, J.
Dover County School for Girls.—Rusbridge, Miss M. J.
Erith County School.—Smith, A. S. D
Faversham: New Herrlingen School.—Prag, A.
Folkestone County School for Girls.—Binden, Miss R.
Folkestone: Dover Road Girls' School.—Wright, Miss A. J.
Gillingham: Medway Technical College.—Woodcock, A. J. A.
Gravesend County School for Boys.—Lister, S.; Walker, E. W.
Maidstone Grammar School.—Manning, W.
Maidstone Grammar School for Girls.—Brook, Miss S.; Cooper, Miss H. M

KENT—Contd.
Matfield: The Grange.—Hodgson, O.
Ramsgate: St. Lawrence College.—Dare, A. G.
Rochester Grammar School for Girls.—Kursop, Miss K. P.
Sandwich: Manwood's Grammar School.—Rock, G. E.
Sevenoaks School.—Rollett, A. P.; Smith, A. A.
Sheerness Technical Institution.—Ashley, G. E.
Sittingbourne County School for Girls.—Richards, Miss E. M
Sturry: Milner Court.—Juckes, R.
Tonbridge County School for Boys.—Fayerman, W. M.
Tonbridge County School for Girls.—Warren, Miss K. M.
Tonbridge School.—Gordon, C. B.; Grenfell, D. A.

LANCASHIRE.

Ashton-under-Lyne: Secondary School.—Booth, N.; Jackson, G. B.
Ashton-in-Makerfield: Grammar School.—Hall, F. G.
Bacup and Rawtenstall Grammar School.—Anstey, J. G.
Barrow-in-Furness Grammar School for Boys.—Johnson, B.
Barrow-in-Furness Grammar School for Girls.—Wood, Miss E.
Blackburn: Queen Elizabeth's Grammar School.—Gregory, R. K.; Holden A.; Kennedy, H.
Blackburn Girls' High School.—Mosley, Miss E.
Blackpool: Collegiate School for Girls.—Clark, Miss J.
Blackpool: Arnold High School for Girls.—Thomas, Miss M. B
Birkdale: Stoneycroft.—Pinnington, Miss L.
Bolton Municipal Secondary School.—Hoyle, Miss R.
Burnley Grammar School.—Evans, H. F.; Wren, J. C. E.
Bury Grammar School for Girls.—Smale, Miss S. E. B.
Chadderton Grammar School.—Smith, J. S.
Chorley Grammar School.—Henderson, F. W.
Clitheroe: Royal Grammar School for Girls.—Ellsmoor, Miss L. A.
Colne Grammar School.—Kellaway, W. G.
Darwen Grammar School.—Kay, F.
Fleetwood: Rossall School.—Trist, L. H.
Hutton Grammar School.—Ashburner, A. E.
Lancaster: Friends' School.—Harbisher, S.
Lancaster: Girls' Grammar School.—Lister, Miss F.
Lancaster: Royal Grammar School.—Tarver, J. E.
Leigh Grammar School.—Young, B.
Liverpool, Great Crosby: Merchant Taylors' School for Girls.—Williamson, Miss A. F. A.
Liverpool: Holly Lodge High School.—Leake, Miss A. E.
Liverpool: Holt School.—Jones, F. K.
Liverpool College.—Bolland, A. K.; Prestwich, A. R.
Liverpool: Calder High School.—Edmunds, Miss E. J.
Liverpool Institute.—Baxter, H. A.; Reece, F. W.
Liverpool Institute High School for Girls.—McCormick, Miss E. M.
Liverpool: Mount Pleasant Training College.—Taylor, Miss C.
Liverpool: Queen Mary High School.—Mielziner, Miss D. J.
Liverpool: St. Francis Xavier's College.—Dunn, D.

LANCASHIRE—Contd.

Liverpool University.—Fletcher, Dr. A.; Proudman, Prof. J.; Walker, Dr. A. G.

Liverpool: Waterloo Park School for Girls.—Cobban, Miss N. L.

Lytham: Queen Mary School.—Lofthouse, Miss F. W.

Manchester: Broughton High School.—Tanner, Miss M. L.

Manchester Central High School.—Clayton, J. A.; Hindley, J. P.

Manchester College of Technology.—Bowman, F.; Hunter, W.

Manchester: Fairfield High School for Girls.—Edwards, Miss E. F.; Stephens, Miss M. O.

Manchester Grammar School.—Chevalier, R. C.; Lob, H.

Manchester High School for Girls.—Holman, Miss E. M.; Seddon, Mrs. W. L.

Manchester: Hulme Grammar School.—Dennis, T.; Eyre, P. J.; Wood, E. L.

Manchester: Levenshulme High School for Girls.—Holgate, Miss F. M.

Manchester: North Manchester Municipal High School.—Light, K. G.

Manchester: Stretford Grammar School.—Dakin, A.; Rutland, V. D. H.

Manchester: Whalley Range, High School for Girls.—Anderson, Miss A. M.; Garner, Miss W.

Manchester University.—Hartree, Prof. D. R.; Swirles, Dr. B.

Newton-in-Makerfield Grammar School.—Smith, J. E.

Ormskirk: Edge Hill Training College.—Cook, Miss H. M.

Orrell: Upholland Grammar School.—Thomas, J.

Preston: The Park School.—Blackburn-Brown, Miss E. M.

Preston: Winckley Square Convent School.—Wahltuch, Mother Mary Cephas; Smith, Miss M. C.

Rivington and Blackrod Grammar School.—Saxelby, C. H.

St. Helen's: Cowley Girls' School.—Willis, Miss M.

Salford: Broughton High School.—Verney, Miss D.

Salford Grammar School.—Roxby, B. G.

Salford: Pendleton High School for Girls.—Brown, Miss M.

Salford: Royal Technical College.—Rolfe, C. G.

Southport: King George V School.—Mayne, W. L.

Southport: University School.—Crosley, G. D.

Ulverston Grammar School.—Crosland, L.

Warrington Secondary School.—Broome, J. S.

Waterloo-with-Seaforth Grammar School.—Baldwin, E.

Whitefield: Stand Grammar School.—Locke, G. T.

Widnes: Wade Deacon Grammar School.—Hope, C.; Owen, Miss E.

Wigan Grammar School.—Boswell, J.; Turton, A.

Wigan: Upholland College.—Kieran, Rev. F. P.

LEICESTERSHIRE.

Ashby de la Zouch Girls' Grammar School.—Fleming, Miss A. M.

Leicester City Boys' School.—Carpenter, A. G.

Leicester Collegiate Girls' School.—Ashby, Miss W.; Smith, Miss D. R.; Walter, Miss M. L.

Leicester: Gateway School.—Bush, F. J.

Leicester: Wyggeston Grammar School for Girls.—Hern, Miss E. A.; Stenhouse, Miss S. E.

LEICESTERSHIRE—Contd.
Loughborough College.—Dain, F. R.; Homer, J. B.
Loughborough Grammar School.—Trowbridge, W. H.
Loughborough: Junior College (County Secondary School for Boys).—Eggington, A. I.
Market Harborough: Grammar School of King Edward VII.—Harris, P. J.
Market Harborough: Nevill Holt Preparatory School.—Cook, E. E.

LINCOLNSHIRE.

Barton-on-Humber Grammar School.—Nightingale, M. C.
Boston Grammar School.—Border, G. W.
Boston High School.—Bolton, Miss G.
Brigg Grammar School.—Knight, A. E.
Gainsborough High School.—Wood, Miss M. K.
Grantham: King's School.—Marks, H. F.
Grimsby: Wintringham Secondary School.—Ralph, D.
Lincoln Girls' High School.—Baylis, Miss B. M.; Scoular, Miss E. M. E.; Wilson, Miss J.
Louth: King Edward VI Grammar School.—Foster, T. H.
Louth: King Edward VI Grammar School for Girls.—Phillips, Miss C. E.; Porteous, Miss M. F.
Spalding High School for Girls.—Ralph, Miss M.
Sutton-on-Sea: St. Clement's School.—Young, D. A.

LONDON.

POSTAL DISTRICT E.

Clapton County Secondary School.—Pendry, Miss F. M.
Coborn School for Girls.—Andress, Miss F. M.; Leonard, Miss D. M.
Dalston County Secondary School.—Gooderham, Miss V. W.; Griffith, Miss M. J.; Sexton, Miss E. C.
East Ham Girls' Grammar School.—Heward, Miss D. A.
Forest Gate: St. Angela's High School.—Gibson, Miss M. E.
Hackney Downs School.—Kershaw, J.; Swan, F. J.
Leytonstone County High School for Girls.—Guttridge, Miss A.; McLachlan, Miss H.
Mile End Road: Queen Mary College.—Green, S. L.
Stepney: Raine's Boys' Secondary School.—Andrews, S. T. G.; Tyler, G. D.
Stepney: Raine's Girls' Secondary School.—Janes, Miss W. G.
Walthamstow County High School.—Goldwin, Miss M. B.
Walthamstow: Forest School.—Venning, D. L.
Walthamstow: Sir George Monoux Grammar School.—Rayner, S. H.; Taylor, T. C.
Wanstead County High School.—Baker, B.; Swaine, K. B.
West Ham Grammar School.—Kelly, V. P.
West Ham Secondary School.—Brown, F. G. W.; Holmes, R.

POSTAL DISTRICT E.C.
Aldgate: Sir John Cass Institute.—Church, Dr. A. E. R.
Breams Buildings: Birkbeck College.—Fox, Dr. C.; Greenwood, Dr. T.; Smart, E. H.

LONDON—Contd.

POSTAL DISTRICT E.C.—Contd.

Clerkenwell: Northampton Polytechnic Institute.—Geary, A.
Cowper Street: Central Foundation Boys' School.—Gibbins, N. M.; Spencer, T. A. J.
Gresham Street: Gresham College.—Wagstaff, Prof. W. H.
Holborn: Mercers' School.—Fyson, H.
Owen's Row: Dame Alice Owen's School.—Bozman, Miss A. M.
Victoria Embankment: City of London School.—Nobbs, C. G.

POSTAL DISTRICT N.

Edmonton: Latymer School.—Abley, L. A. V.
Finchley: Woodhouse School.—Brosgall, J.
Highbury County School.—Chapman, A. P.; Retter, C. F.
Highbury Hill High School.—Evans, Miss W. A.
Holloway: Northern Polytechnic.—Gardner, G. A.; Martin, Dr. E. S.
Hornsey High School.—Hampson, Miss M.; Legon, Miss C. T.; Sharman, Miss M.
Hornsey: Stationers' Company's School.—Vesselo, I.
Southgate: Minchenden Secondary School.—Hurd, H. W.
Stamford Hill: Skinners' School for Girls.—Diaper, Miss G.
Tottenham County School.—Wright, G. H.
Tottenham: Downhills Central School.—Bullen, G. A.
Tottenham High School.—Gurry, Miss H. M.; Hewlett, Miss C. G.
Wood Green: Glendale County School.—Blamey, J. E.
Wood Green: Providence Convent.—Harwood, Miss M. K. B.
Wood Green: Trinity County School.—Swinden, L. A.

POSTAL DISTRICT N.W.

Brondesbury and Kilburn High School.—Williams, Miss M. L.
Brondesbury: Maria Grey College.—Bowman, Miss M. E.
Camden Town: North London Collegiate School.—Bennett, Miss A. E.; Leese, Miss S. M.; Rigby, Miss K. W.; Starkey, Miss D. M.
Clarendon Square: St. Aloysius Convent.—Rawson, Miss M.
Gospel Oak: William Ellis School.—Mamlock, P.
Hampstead: Haberdashers' Aske's School.—Watkins, C. S.
Hampstead: The Hall.—Montefiore-Castle, D. L.
Hampstead: King Alfred School.—Sheppard, N. F.
Hampstead: University College School.—Hills, F. A.; Mead, L. F. W.
Hampstead: Westfield College.—Stanley, Miss G. K.
Kentish Town: Camden School for Girls.—Butterworth, Miss F.
Kentish Town: North-Western Polytechnic.—Lowery, Dr. H.
Kilburn Grammar School.—Bentley, W. H. E.; Walters, G. W.
Marylebone: St. Marylebone, Grammar School.—Gibson, G. E. G.; Willis, R. W.
Mill Hill: Copthall County School.—Down, Miss E. M.; Heys-Jones, Miss M. B.
Parliament Hill School.—Edington, Miss E. M.; Pollard, Miss M.
Regent's Park: Bedford College.—Hall, Miss A. L.
Willesden County School.—Smith, P. J.
Willesden Technical College.—Clitheroe, L.

LONDON—Contd.

POSTAL DISTRICT S.E.

Brockley County School.—Sinclair, Dr. G. I.

Camberwell: Charles Edward Brooke School.—Brookes, Miss M. L.; **Green,** Miss M. E.

Catford: Lewisham Prendergast School.—Thompson, Miss A. H.

Downham L.C.C. Central School.—Burdon, J. H.

Dulwich Central School.—Weeks, G. A.

Dulwich College.—Dixon, Rev. H. H.; Fletcher-Jones, A. A.; **Lax, E.**; Styler, H. V.

Dulwich High School.—Insley, Miss G. M.

Dulwich: James Allen's Girls' School.—Edwards, Miss E. M.

Eltham: Avery Hill Training College.—Exton, Miss G.

Eltham College.—Ade, F. C.

Eltham Hill School.—Canter, Miss E.; Lake, Miss D.

Gipsy Road Junior Mixed L.C.C. School.—Foster, R. G.

Gravel Lane: John Harvard L.C.C. Senior Boys' School.—**Betts, E. H.**

Greenwich: The Roan School for Boys.—Daltry, C. T.

Greenwich: Royal Naval College.—Broadbent, T. A. A.; **Milne-Thomson,** L. M.

Hatcham: Haberdashers' Aske's Girls' School.—Mellor, Miss D. L.

New Cross: Addey and Stanhope School.—Howard, B. A.; **Withrington,** J. W.

New Cross: Goldsmiths' College.—Ayres, F.; Trubridge, Dr. G. F. P.; Williams, Mrs. E. M.

Plumstead: The King's Warren School.—Pinhorn, Miss L. G.

Southwark: Notre Dame High School.—O'Loghlen, Miss H.

Sydenham County Secondary School for Girls.—Butler, Miss A. K.; Seymour, Miss P.

Sydenham High School.—Harrison, Miss E.

Tower Bridge: St. Olave's School.—Cramp, L. J.; Firth, F. G.; **Yorke, S. V.**

Woolwich Central School.—George, C. H.

Woolwich Polytechnic.—Bartram, C. W.; Lowry, H. V.

Woolwich: Royal Military Academy.—Beaven, C. L.; **Roberts, W. M.**; Sisson, G. R.

POSTAL DISTRICT S.W.

Battersea Grammar School.—Beaney, K. J.

Battersea Polytechnic.—Harvey, F. W.; Hayden, Dr. H. A.; **Paradine,** C. G.

Battersea: Sir Walter St. John's School.—Stripp, A. G.

Chelsea: Carlyle School.—Finney, Miss A. B. D.

Clapham College.—Sheppee, H. V.

Clapham County Secondary School.—Rotherham, Miss E. M.

Earl's Court School of the Holy Family.—Morton, Sister **Dorothea C.** H. F.

Elm Park: Strand School.—King, W. H.

Fulham County Secondary School.—Atkinson, Miss E. D. C.; **Jameson,** Miss A.

Kensington: Cardinal Vaughan School.—Honan, T. A.

Merton Road: Elliott Central School for Girls.—**Westmoreland-White,** Mrs. B.

LONDON—Contd.

POSTAL DISTRICT S.W.—Contd.

Parsons Green: Lady Margaret School.—Winchester, Miss J.

Putney County Secondary School.—Hitchman, Miss K. A.; Ironside, Miss M. A.; Woods, Miss M. F.

Putney High School.—Westbury, Miss G. E.

Raynes Park County School for Boys.—Courchée, H. B.; Raynham, E. G.

Roehampton: Convent of the Sacred Heart.—Hogg, Madame, B.

Roehampton Lane: Froebel Educational Institute.—Sherriff, Miss C. W. M.

Roehampton: Manresa House.—O'Hara, Rev. C. W., S. J.

S. Kensington: City and Guilds College.—Ehrenborg, G. B.; Hatley, A. J.

S. Kensington: Imperial College Of Science and Technology.—Bickley, Dr. W. G.

Streatham: Furzedown College.—Stimson, Miss C.

Streatham Hill High School.—Gwatkin, Miss E. R.; Hartwell, Miss W. A.

Tooting: Bec School.—Brown, M. W.; Hooper, J. H.

Wandsworth: Emanuel School.—Spafford, L. W.

Wandsworth Technical Institute.—Wallis, B. C.

Westminster College.—Ross, J. S.; Toll, C. S.

Westminster: Grey Coat Hospital.—Trickey, Miss E. M.

Westminster School.—Fisher, C. H.; Murray-Rust, T. M.

Wimbledon County School for Girls.—Dean, Miss J. E.

Wimbledon High School.—Whiting, Miss M. H.

Wimbledon: King's College School.—Lecomber, H.

POSTAL DISTRICT W.

Acton: Haberdashers' Aske's Girls' School.—Gray, Miss V. L.

Acton Technical College.—Barclay, W.; Simons, B.

Brook Green: St. Paul's Girls' School.—Cumber, Miss E.; Gent, Miss P. M.; Lehfeldt, Miss W. M.; McIntosh, Miss K. W.

Ealing County School for Boys.—Sampson, A. J.

Ealing County School for Girls.—Hathaway, Miss E. R.; Merriman, Miss D. E.

Hammersmith: Colet Court.—Cox, S. H. J.

Hammersmith: Convent of the Sacred Heart.—Vieyra, Miss M.

Hammersmith: Godolphin and Latymer Girls' School.—Barnard, Miss E. L.; Mathews, Miss A.

Hammersmith: St. Paul's School.—Heath, A. C.

Harley Street: Queen's College.—Shuttleworth, Mrs. E.

Kensington High School.—Mackintosh, Miss C. T.

North Paddington Central School.—Shavelson, Miss A.

Regent Street Polytechnic.—Allen, Miss H. V.

POSTAL DISTRICT W.C.

Gower Street: University College.—Filon, Prof. L. N. G.; Jeffery, Prof. G. B.

Kingsway: International Correspondence Schools.—Gillespy, G. T.

Southampton Row: Institute of Education.—Black, M.; Hamley, Prof. H. R.; Lauwerys, J. A.

Strand: King's College.—Combridge, J. T.; Henderson, Dr. J.; Shovelton, S. T.; Temple, Prof. G. F. J.

MIDDLESEX.

Ashford: Muncaster School.—Marshall, R. L.
Ashford: Welsh Girls' School.—Edwards, Mrs. L. E.
Burnt Oak: Goldbeaters Senior School.—Howell, H. W.
Enfield County School for Girls.—Florence, Miss I. C.
Enfield Grammar School.—Birbeck, H. L.; Mabbott, H. A.
Hampton: Lady Eleanor Holles School.—Cross, Miss G. E.; Nye, Miss P. M.
Harrow County Boys' School.—Cyster, R. F.; King, R. S.
Harrow County Girls' School.—Hoare, Miss K. N. H.
Harrow: Heathfield High School.—Morris, Miss M.
Harrow School.—Dockeray, N. R. C.; Hughes, R. T.; McConnell, G. R.; Morris, R. W.; Snell, K.S.
Harrow: Southlands.—Beeching, Miss A. V.
Hillingdon: Bishopshalt School.—Clarke, L. W.
Isleworth: Borough Road College.—Page, Dr. A
Isleworth County School.—Inman, S.
Isleworth: Gumley House.—Coates, Mrs. N. E.
Isleworth: Spring Grove Secondary School.—Brown, F. W.
Northwood: Merchant Taylors' School.—Hodgetts, W. J.; Lloyd, D. C.; Parsons, G. L.; Pears, Dr. L. R.
Pinner, Eastcote: St. Michael's School.—Beeny, F. W.
Southall County Secondary School.—Dunbar, Miss E. A.
Twickenham County School.—Gaskin, Miss N. F.

NORFOLK.

Downham Market Secondary School.—Brief, M.
Great Yarmouth Grammar School.—Nelkon, M.; Palmer, A. H. G.
Great Yarmouth High School for Girls.—Adams, Miss M. L.; Taylor, Miss M.
Holt: Gresham's School.—Colombé, P. V. A.; Douglas, A. B.; Newell, P. S.
Norwich: Blyth Secondary School.—Saunders, Miss N. L.
Norwich: City of Norwich School.—Whitehead, P.
West Norfolk and King's Lynn High School.—Ince, Miss G. M.; Thomas, Mrs. T. L.

NORTHAMPTONSHIRE.

Kettering High School for Girls.—Ives, Miss E. M.
Northampton High School.—Gibbins, Miss E. M. E.
Northampton School for Boys.—Richmond, C. A.
Northampton School for Girls.—Batson, Miss J. M.
Northampton Town and County School.—Swinden, B. A.
Oundle School.—Black, J. A. E.; Brewster, G. W.; Jackson, F. T.
Peterborough County School for Girls.—Leach, Miss E. F.
Peterborough: The King's School.—Larrett, W. D.
Towcester Grammar School.—Grandorge, J. R.

NORTHUMBERLAND.

Alnwick: The Duchess's School.—Lowther, Miss P.; Watson, Miss M.
Morpeth High School.—Hughes, Miss M. S.
Newcastle-upon-Tyne: Bolam Street School.—Knighting, E.
Newcastle-upon-Tyne: Central Newcastle High School.—Linfield, Miss E.; Thubrun, Miss N.

NORTHUMBERLAND—Contd.

Newcastle-upon-Tyne: Church High School.—Forster, Miss A. K.; Shilston, Miss G. M.

Newcastle-upon-Tyne: Dame Allan's Boys' School.—Mallinson, H.; Wilson, A. K.

Newcastle-upon-Tyne: Heaton Secondary School for Boys.—Fletcher, A.

Newcastle-upon-Tyne: Heaton Secondary School for Girls.—Garratt, Miss D.

Newcastle-upon-Tyne: Kenton Lodge Training College.—Smith, Mrs. E. Wardley.

Newcastle-upon-Tyne: King's College.—Bullerwell, J. W.; Caunt, G. W.; Goldsbrough, Prof. G. R.; Havelock, Prof. T. H.; Wood, J. F.

Newcastle-upon-Tyne: Royal Grammar School.—Boll, W. H.; Johnson, E.; Macro, W. B.

Newcastle-upon-Tyne: Rutherford College Girls' School.—Gibbon, Miss D. Pochin, Mrs. A.

North Shields: Tynemouth Municipal High School.—Shortridge, Miss A.

Tynemouth School.—Darke, G. P.

Whitley Bay: Whitley and Monkseaton High School.—Headford, Miss H. C.

NOTTINGHAMSHIRE.

Heanor County Secondary School.—Hosegood, C. F.

Mansfield: The Brunts School.—Blankley, Miss H.

Mansfield: Queen Elizabeth's Grammar School for Boys.—Exton, R. G.; Eyre, C. G.

Newark High School.—Evans, Miss K. M.

Newark: The Magnus Grammar School.—Talbot, J. W.

Nottingham County Secondary School for Girls.—Chamberlain, Miss K. S.

Nottingham High School for Boys.—Goddard, H.

Nottingham High School for Girls.—Upperton, Miss E.

Nottingham: The Manning School.—Selby, Miss F. H.

Nottingham: University College.—Green, H. G.; Piaggio, Prof. H. T. H.; Prior, L. E.; Underwood, F.

Nottingham, W. Bridgford: County Secondary School.—Bradshaw, W. N.; Midgley, A.

Retford: King Edward VI Grammar School.—Gover, D. F.

Southwell: Minster Grammar School.—Doy, D. H.

Worksop College.—Dronfield, J.; O'Meara, G. A.; Osborne, S. J.; Thatcher, A. M.

OXFORDSHIRE.

Burford Grammar School.—Clayton, Miss R. A.

Chipping Norton County School.—Miles, L.

Henley-on-Thames Grammar School.—Potter, J. F.

Oxford: Brasenose College.—Griffith, I. O.; Stocker, W. N.

Oxford: Headington School.—Mallett, Miss F. E.

Oxford: Hertford College.—Ferrar, W. L.

Oxford: Lady Margaret Hall.—Wrinch, Dr. D. M.

Oxford: Magdalen College.—Dixon, Prof. A. L.

Oxford: Magdalen College School.—Cox, H. J.

Oxford: Queen's College.—Haslam-Jones, U. S.

Oxford: St. Edward's School.—McMichael, J. F.

RUTLAND.

Uppingham School.—Crofts, J. R.; Dunbar, D. S.; Kendall, E. S.

SHROPSHIRE.

Newport: Adams' Grammar School.—Kilgour, J.
Oswestry Girls' High School.—Pengilly, Miss K. M.
Salisbury: Bishop Wordsworth's School.—Davis, E. S.
Salisbury Training College.—Stevenson, Miss E. H.
Shrewsbury: Mill Mead School.—Beddow, A. J. C.
Shrewsbury: Priory School.—Burrow, S. M.
Shrewsbury: Priory County School for Girls.—Cooke, Miss D. M.
Shrewsbury School.—Childs, P.; Hadland, F. S.; Harvey, L. F.
Wellington: Wrekin College.—Kirkwood, H. R.
Wem: Adam's Grammar School.—Ashwin, W. F.

SOMERSET.

Bath: City of Bath Boys' School.—Burn, E. W.
Bath: Kingswood School.—Berry, H.; Tongue, F. J.
Bath: Monkton Combe School.—Wicks, A. T.
Bruton: Sexey's School.—Barnes, W. C.
Chard School.—Eyres, N. R.
Frome County School.—Barnard, G. S.
Ilminster Grammar School.—Maker, A. D.
Midsomer Norton County Secondary School.—Oldham, D. H.
Minehead County School.—May, A. J. G.
Taunton: Bishop Fox's Girls' School.—Swann, Miss K. M.
Taunton: King's College.—Hippisley Jones, I. F.
Taunton: Queen's College.—Wiseman, C. L.
Taunton School.—Evans, J. B.; Middleton, D. H.
Wells: Blue School.—Hattam, M.
Wellington School.—Farrar, E.
Winscombe: Sidcot School.—Armitage, F. W.

STAFFORDSHIRE.

Brierley Hill: Intermediate School.—Williams, S. E.
Burton-on-Trent Grammar School.—Cooper, G. H.
Darlaston Intermediate School.—Hicks, J. E.
Hanley High School.—Diggles, R. E.; Quinton, J.
Newcastle High School.—Page, G. F.; Smith, J. W. A.
Newcastle: Orme Girls' School.—Wark, Miss J. P.
Rocester: Abbotsholme School.—Chick, L. H.
Smethwick: Holly Lodge High School for Boys.—Trustram, S. F.
Smethwick: Holly Lodge High School for Girls.—Hardcastle, Miss L. E.; Morley, Miss G.
Stafford Girls' High School.—Davis, Miss M. W.
Stafford: King Edward VI School.—Beck, H. O.
Stone: Alleyne's Grammar School.—Beardsmore, T. A.

STAFFORDSHIRE—Contd.

Walsall: Edward Shelley Central School.—Riley, A. W.
Walsall: Queen Mary's High School for Girls.—Reid, Miss D. G.
Wolstanton County Grammar School.—Stevens, G. H.
Wolverhampton Grammar School.—Jones, V. H.; Sheen, G.
Wolverhampton Municipal Secondary School.—Bridgeman, J. W.; Tranter, H. H.

SUFFOLK.

Bury St. Edmunds: Culford School.—Blamey, F. E.
Bury St. Edmunds: West Suffolk County School.—Fawkes, W. F.
Felixstowe College for Girls.—Jones, Miss R. M.
Haverhill Secondary School.—Phillips, A. G.
Ipswich High School.—Esam, Miss E. E.
Ipswich: Northgate School for Boys.—Lewis, J.
Ipswich: Northgate School for Girls.—Campbell, Miss J. M.
Sudbury Grammar School.—Rees, J. E.

SURREY.

Camberley County School.—Worthington, A. A.
Chertsey: Ottershaw College.—Brookes, B. C.
Croydon High School.—Crompton, Miss A. G.
Croydon: Selhurst Boys' Grammar School.—Katz, J.
Croydon: Selhurst Girls' Grammar School.—Barnes, Miss E.
Croydon: Whitgift Middle School.—Taylor, Dr. A. J.
Croydon: Whitgift School.—Cummings, J.; Palmer, A. H. G.; Parr, H. E.
Englefield Green: Royal Holloway College.—Pick, Miss M.; Sargent, Miss W. L. C.
Epsom College.—Thomas, Rev. S. H.
Epsom: Rosebery County School for Girls.—Ball, Miss E. F.
Farnham: The Army College.—Smith, H. C.
Farnham Grammar School.—Munton, E.
Godalming: Charterhouse.—Barton, E.; Chignell, N. J.; Hollowell, P. W. C.; Morris, T. D.
Godalming County School.—Webb, E. W.
Guildford County School for Girls.—Day, Miss N. H.; Wright, Miss H. M.
Guildford: Cranleigh School.—Hall, E. R.
Guildford: Edgeborough.—Mitchell, C. B.
Hindhead: Amesbury School.—Hill, J. G.
Hindhead: Grove School.—Fletcher, W. C.
Kingston-on-Thames Grammar School.—Wadley, H. W. A.
Kingston-on-Thames: Tiffin Girls' School.—Mead, Miss M. J.; Unwin, Miss G. W.
Leatherhead: St. John's School.—Grigg, D. R.
Mitcham County School for Girls.—Chopping, Miss G.; Lewis, Miss F. M.
Oxted County School.—Bennett, Miss W. E.
Purley: Commonweal Lodge School.—Beggs, Miss M. A.; Newby, Mrs. M.
Purley: Downside School.—Turtle, Comr. E. B.
Reigate County Secondary School for Girls.—Perren, Miss C. E.
Reigate Grammar School.—Atkinson, C.

SURREY—Contd.
Richmond Boys' County School.—Parker, W. T. G.
Richmond Central School for Boys.—Hamilton, J. H.
Richmond Girls' County School.—Jarvis, Miss D. M.
Surbiton County School.—Willis, A. G. F.
Sutton County School.—Batten, T. C.
Sutton High School.—Hamand, Miss T. M.
Sutton: St. Norbert's Preparatory School.—Gloyne, R. W.
Wallington County School for Girls.—Cullis, Miss E.
Wallington: Dinorben High School.—Morris, Miss R. E.
Woking County School for Girls.—Hicks, Miss H. R.
Whyteleafe County School for Girls.—Osborn, Miss F. A.
Purley County School for Boys.—Clemow, J.; Owen, S. J.
Purley County School for Girls.—Akhurst, Miss E. G.; Page, Miss A. M.

SUSSEX.

Bexhill-on-Sea: County School for Girls.—Pool, Miss W. M.
Bognor Regis: S. Michael's.—Christison, Miss M. F.
Brighton: The College.—Lester, R. E.
Brighton and Hove High School.—Sandamare, Miss K.
Brighton: Roedean School.—Tredgold, Miss J. A.
Brighton: Varndean School.—Chaffer, F. T.
Brighton: Varndean School for Girls.—Craig, Miss P. E.; Marshall, Miss F. L.; Turner, Miss W. M.; Warmington, Miss M. P.
Chichester High School for Boys.—Stephenson, C. W.
Crawley: Milton Mount College.—Wood, Miss D.
Crawley: Upland House, Buchan Hill.—Walters, G. L.
Eastbourne College.—Bowman, T. E.
Eastbourne High School.—Aslin, E. L.
Eastbourne: St. Andrew's School.—Fewings, J. A.
Eastbourne: St. Winifred's.—Silow, Miss E. M.
East Grinstead: Brambletye.—Griffith, M. D.
Hassocks: Belmont School.—Burr, M. de W.
Hastings Grammar School.—Baker, L. H. G.
Horsham: Christ's Hospital.—Armitstead, W.; Crabbe, J. R.; Humphrey, C. A.; Manisty, J. C.; Waddams, L. T.
Horsham: Collyer's School.—Locke, C. S.
Hove County School for Girls.—Jones, Miss E. E.
Lewes County School for Girls.—Hutson, Miss M.
Ore: Hurst Court.—Elliott, K. G. I.
St. Leonard's-on-Sea: Uplands School.—Brett, Miss D.; Davey, Miss R. G.
Seaford College.—Guillebaud, P. D.
Seaford: St. Peter's.—Talbot, B. L.
West Worthing: St. Dunstan's.—Jackes, W. E.

WARWICKSHIRE.

Alcester Grammar School.—Caton, C. T. L.
Birmingham, Aston: King Edward's Grammar School.—Pedley, E. R.
Birmingham, Camp Hill: King Edward VI Grammar School for Boys.—Hinckley, A.
Birmingham: Edgbaston High School.—Cook, Miss W. M.

WARWICKSHIRE—Contd.

Birmingham, Edgbaston: St. Paul's High School.—Meixner, F.

Birmingham, Edgbaston: West House School.—Hewitson, Miss F.

Birmingham: Erdington Secondary School for Girls.—Bennell, Miss M. M.; Fowler, Miss E. T.

Birmingham, Five Ways: King Edward's Grammar School.—Fulford, R. J.

Birmingham: George Dixon Secondary School for Boys.—Worthington, E.

Birmingham: George Dixon Secondary School for Girls.—Boyter, Miss M. P.; Shuker, Miss E. E.

Birmingham: Ingleton Road Junior and Infant School.—Smith, J.

Birmingham: King Edward's School.—Porter, M. A.; Roberts, J. C.; Smith, E. V.

Birmingham: King Edward's High School.—Craig, N. J. F.; Jackson, A.

Birmingham: King's Norton Secondary School for Girls.—Read, Miss M. E.

Birmingham: Langley County High School.—Williams, Miss D.

Birmingham: Moseley Secondary School.—Hill, C. H.; Welford, P. G.

Birmingham: Oldbury County High School.—Richards, J. B.

Birmingham: Saltley Secondary School.—Cooke, H. K.

Birmingham University.—Cull, E. C.; Hammond, Miss M.; Watson, Prof. G. N.

Birmingham: Waverley Secondary School.—Guilbert, W. F.; Whiteley, F. P.

Birmingham: Yardley Secondary School.—Allender, A. G.; Marsh, A. H. W.

Coventry, Bablake School.—Bridger, H.

Coventry: Barr's Hill School.—Wilson, Miss D.

Coventry: King Henry VIII School.—Howard, W. H.

Coventry Technical College.—Curtis, F. R.

Hockley Heath: Pachwood Haugh.—Soden, H. C.

Leamington College.—Onslow, F. W.

Leamington High School.—Sweet, Miss D. A.

Nuneaton High School.—Butler, Miss E. G.

Nuneaton: King Edward VI School.—Pratt, A. S.; Whittaker, A.

Rugby High School.—Randall, Miss G. F.

Rugby: Lawrence Sheriff School.—Smith, A. McL.

Rugby School.—Carey, R. M.; Channon, J. B.; Larmour, J.; Megson, M.; Sparling, H. P.

Solihull: Eversfield Preparatory School.—Denney, C. W.

Solihull School.—Thompson, A. R.

Warwick: King's High School for Girls.—Lord, Miss P. G.; Naish, Miss E. M.

WESTMORLAND.

Heversham School.—Corbett, A. D.

Kirkby Lonsdale: Queen Elizabeth School.—Deane, F. S.

WILTSHIRE.

Marlborough College.—Edgar, J. A.; Kalaugher, W. G.; Kempson, E. G. H.; Maples, B. A.; Middleton, T. W. B.; Nest, H. C.; Robson, A.; Smith, E. D.

Swindon: The College Secondary School.—Pocock, Miss A. M. P.; Thompson, J. R.

Trowbridge: Boys' High School.—Downing, H. J.

West Lavington: Dauntsey's School.—Tennant, W.

WORCESTERSHIRE.

Dudley Girls' High School.—Carter, Miss M.
Dudley Grammar School.—Allman, G.
Halesowen Grammar School.—Emsden, P. R.
Hartlebury Grammar School.—Keeling, J.
Kidderminster High School.—Leigh, Miss C. M.
Malvern College.—Cobb, R. H.; Meade-King, O.; **Willis**, R. W. G.
Stourbridge: King Edward VI School.—Grocock, T. A.; **Rose**, F. P.
Worcester: Alice Ottley School.—Crawford, Miss I. M.
Worcester City Secondary School for Girls.—Donald, Miss P. T.
Worcester: Secondary School for Girls.—Wallen, Miss H. S. G.
Worcester: Royal Grammar School.—Pullinger, H. R.; **Walker**, A.

YORKSHIRE.

Ackworth School.—Darby, Miss H. M.; **Jevons**, Miss V. M.
Apperley Bridge: Woodhouse Grove School.—Roberts, D. T.
Barnsley Grammar School.—Knight, A.; Powell, C. E.
Batley Girls' Grammar School.—Tesh, Miss G. M.
Beverley Grammar School.—Pearcy, I. H.; **Taylor**, J. A.
Beverley High School.—Davies, Miss M. J.
Bingley Training College.—Capes, Miss G. M.
Bradford: Belle Vue High School for Boys.—Tomkys, W. A.
Bradford: Belle Vue High School for Girls.—Makinson, **Miss** N. I.
Bradford: Bolling High School.—Greene, Miss E.
Bradford Girls' Grammar School.—Dogherty, Miss A.; **Hooke, Miss** M. A.
Bradford Grammar School.—Coppock, S. W.
Bradford: Hanson High School for Boys.—Sunderland, J.
Bradford Technical College.—Curnow, H. J.
Bridlington High School for Girls.—Doughty, Miss M. A.
Bridlington School.—Parkinson, W.
Brighouse Girls' Secondary School.—Robson, Miss A.
Brighouse: Rastrick Grammar School.—Martin, E. W. H.
Cleckheaton: Whitcliffe Mount Grammar School.—McLean, E.
Dewsbury: Wheelwright Grammar School.—Sadler, L.
Doncaster Grammar School.—Anderson, J.
Doncaster High School.—Luddle, Miss P. E.
Doncaster Technical College.—Adams, L. J.
Ecclesfield Grammar School.—Blackwell, A.; Loveday, R.
Halifax Municipal Technical College.—Gregory, B. C.
Hebden Bridge Grammar School.—Eastwood, F. E.
Huddersfield: Holme Valley Grammar School, Honley.—Grattan-Guinness, G. H.
Huddersfield Technical College.—Hudson, J. F.; Milnes, J.; Smith, J. H.
Hull: Boulevard Secondary School.—Scott, A.
Hull Grammar School.—Mayor, F.
Hull: Hymers College.—Egner, W. E.
Ilkley Grammar School.—Evans, R. W.
Keighley Boys' Grammar School.—Cadman, G. E.
Knaresborough: King James's Grammar School.—Ellis, F. F.

YORKSHIRE—Contd.

Leeds Girls' High School.—Swindell, Miss P. M.

Leeds Grammar School.—Montagnon, A.

Leeds: Morley Grammar School.—Barron, G.

Leeds: Roundhay School for Boys.—Hesselgreaves, J. W.

Leeds: St. Michael's College.—Fairclough, Rev. H.

Leeds: Thoresby High School.—Mathews, Miss I. M.

Leeds University.—Brodetsky, Prof. S.; Gabriel, R. M.; Gilham, C. W.; Milne, Prof. W. P.; Smeal, G.; Ursell, H. D.

Middlesbrough: Acklam Hall Secondary School.—Macdonald, T. J.; Page, L.

Middlesbrough: Constantine Technical College.—Daniels, H. B.

Middlesbrough Girls' High School.—Coombs, Miss C. E.

Middlesbrough High School.—Van der Heyden, A. F.

Middlesbrough: Kirby Secondary School.—Stark, Miss G. R.

Normanton Grammar School.—Holden, J. A.

Northallerton Grammar School.—Clark, J. W.

Pontefract: The King's School.—Spensley, L. R.

Pudsey: Technical School and Grammar School.—Oldfield, B.

Richmond High School.—Killingley, D. M.

Ripon Girls' High School.—Howell, Miss F. M.

Ripon: The School.—Langdon-Davies, H.

Ripon Training College.—Hornby, Miss C.

Rotherham: The Grammar School.—Blacklock, J. H.

Rotherham: The Grammar School, Maltby.—Smith, A.

Rothwell Grammar School.—Beardwood, H.

Saltburn High School.—MacGregor, Miss L. M.

Scarborough Girls' High School.—Glauert, Miss E.; Sowden, Miss M. F.

Scarborough: Lisvane School.—Cottrell, W. F.

Sedbergh School.—Poole, H.

Sheffield: Abbeydale Secondary School.—Morris, Miss I.; Shaw, Miss M.

Sheffield: Birkdale Preparatory School.—Butcher, A. L.

Sheffield City Training College.—Cowley, J. W.

Sheffield High School.—Goldsmith, Miss M. E.; Neill, Miss M. M.; Thompson, Miss H.

Sheffield: Nether Edge Secondary School.—Wilkinson, G. W.

Sheffield: Woodhouse Grammar School.—Cunnington, W. J.; Kelso, R. J.

Shipley: Salt Girls' High School.—Dedicoat, Miss D. A.

Skipton Girls' High School.—Lloyd, Miss E.; Wise, Miss E.

Swinton: Moorside Senior School.—Barber, A.

Thorne Grammar School.—Ray, A. G.; Taylor, B. H. T.

Wakefield Girls' High School.—Engledow, Miss G.; Jex-Blake, Miss F. L.

Wakefield Grammar School.—Beaven, J. A. D.

Whitby County School.—Burnham, C. E. A.

Whitby: St. Hilda's School.—Dowsett, Sister Mabel.

York: Ampleforth College.—Dolan, J. P.; Osborne, W. H.; Ricketts, C. C.; White, T. W.

York: Archbishop Holgate's Grammar School.—Ward, G. W.

York: Bootham School.—Lucia, B. C.

York: Mill Mount Secondary School.—Harrison, Miss G.

York Training College.—Edington, J. D.

WALES.

ANGLESEY.

Holyhead County School.—Richardson, S.

CAERNARVONSHIRE.

Bangor County School for Girls.—Reeves, Miss L. E. M.
Bangor: St. Mary's College.—Wilkes, Miss L.
Bangor: University College of North Wales.—Berwick, Prof. W. E. H.
Bethesda County School.—Hughes, L.
Deganwy: Woodlands.—Slater, A. M.
Llandudno: John Bright County School.—Moses, S.
Llanfairfechan: St. Winifred's.—Horner, Miss B.

CARDIGANSHIRE.

Aberayron County School.—Evans, Miss K. M.
Cardigan County School.—Gordon, H.

CARMARTHENSHIRE.

Ammanford: Amman Valley, County School.—Pryce, D. G.
Carmarthen: Queen Elizabeth Grammar School.—Davies, S.
Llandilo County School.—Lewis, Miss S.
Llandovery College.—Hill, Rev T. H. W.
Llanelly Boys' County School.—Richards, I. G.

DENBIGHSHIRE.

Abergele: Lowther College.—Sayers, Miss K. I.
Colwyn Bay County Secondary School.—Lines, L.
Colwyn Bay: Penrhos College.—Leach, Miss A.
Denbigh County School.—Harding, J. W.
Ruabon County Secondary School, for Girls.—Moorhouse, Miss M. A.
Wrexham Boys' Secondary School.—Jones, J.
Wrexham County School for Girls.—Hyden, Miss C.
Wrexham: Grove Park Girls' School.—Brooke, Miss E. M.

FLINTSHIRE.

Hawarden County School.—Bell, J.

GLAMORGANSHIRE.

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Bridgend County School.—Chappell, G. E.
Caerphilly Boys' Secondary School.—Osborne, W. S.
Caerphilly Girls' Secondary School.—Jones, Miss O. M.
Caerphilly Senior Boys' School.—Hughes, W.
Cardiff: Canton High School for Boys.—Davies, A. B.; Reeves, P. H.
Cardiff: Canton High School for Girls.—Dent, Miss E. G.
Cardiff: Cathays High School for Girls.—Weighell, Miss G. M.
Cardiff: Cathays High School for Boys.—Young, S. G.
Cardiff: City of Cardiff High School for Girls.—Dockray, Miss F. A.

GLAMORGANSHIRE—Contd.

Cardiff High School for Boys, Newport Road.—Davies, A. G.
Cardiff: Howard Gardens High School for Boys.—Attfield, E. M.; Davies, N
Cardiff: Howard Gardens High School for Girls.—Pye, Miss F. A.
Cardiff Technical College.—Buxton, A.; Watts, F. C.
Cardiff: University College.—Livens, G. H.; Pope, A. H.; Taylor, D. G
Ferndale Secondary School.—Howells, E.
Hengoed: Gelligaer Girls' County School.—Churchill, Miss M. M.
Llandaff: Howell's School.—Tonkin, Miss L. S.
Merthyr Tydfil: Cyfarthfa Castle Municipal Secondary Girls' School.—Morgan, Miss Ellen M.
Neath County School for Girls.—Brooks, Miss M
Neath: The Mining and Technical Institute.—Howell, Dr. W. G.
Penarth County School for Boys.—Jenkins, S. L.; Tuck, T. S. P.
Pengam: Lewis School.—Richards, N.
Pontycymer: Garw Secondary School.—Rees, W. L.
Pontypridd Girls' Intermediate School.—Morgan, Miss F. E. M.
Porth County School for Girls.—Williams, Miss A.
Porth Secondary School.—Kingdon, P. S. T.
Port Talbot County School.—Davies, W. T.; Foulkes, H. O.; Reynolds, C.
Swansea: Glanmôr Secondary School for Boys.—Chapple, M. T.
Swansea: Glanmôr Secondary School for Girls.—Pauls, Miss F. M.
Swansea Grammar School.—Foulkes, T. G.; Morgans, J. G.
Swansea Technical College.—Atkins, E. R.
Swansea Training College.—Hallum, Miss K. C.
Swansea: University College.—Richardson, Prof. A. R.
Treforest Intermediate School for Girls.—Lewis, Miss O. M.; Morgan, Miss Elsie M.

MERIONETHSHIRE.

Barmouth County School.—Morris, W. D.
Towyn County Intermediate School.—Jones, J.

MONMOUTHSHIRE.

Abergavenny County High School for Girls.—Pearce, Miss V. E.
Monmouth School.—Dixon, Ll.
Newport High School for Girls.—Carter, Miss E. G.
Newport Secondary School for Boys.—Atkinson, E. J.
Newport Secondary School for Girls.—Hudson, Miss E.
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Pontypool County School for Girls.—Morgan, Miss M. E. M.
Pontypool: The College.—McIntyre, Miss J.
Tredegar County School.—Edwards, H. J.

MONTGOMERYSHIRE.

Llanidloes County School.—Thomas, R. H.

PEMBROKESHIRE.

Fishguard County School.—Ractliffe, J. F.
Milford Haven County School.—Finney, R. R.; Williams, Miss B.
Narberth County School.—Roberts, J. D.

SCOTLAND.

ABERDEEN.

Aberdeen Grammar School.—Gray, A. H.
Aberdeen: Robert Gordon's College.—Thomson, W. G.
Aberdeen Training Centre for Teachers.—Milne, J.
Turriff Secondary School.—Jockel, C. L. M.

ANGUS.

Dundee: Morgan Academy.—Collier, D. E.
Dundee: University College.—Copson, Prof. E. T.
Montrose: The Academy.—Straiton, G. I.

AYR.

Ayr Academy.—Stratton, R. T.
Cumnock Academy.—Martin, A.
Dalry Secondary School.—Brown, G.
Girvan: Sacred Heart's School.—Langford, Dr. C. D.

BERWICK.

Eyemouth High School.—Craig, W. S.

DUMFRIES.

Dumfries Academy.—Halliday, J. A.

EAST LOTHIAN.

North Berwick High School.—Brown, J. T.; Manson, C. W. M.

FIFE.

Cupar: Bell-Baxter School.—Inglis, Dr. A.
St. Andrews: St. Leonards School.—Herman, Miss M. E. A.
St. Andrews University.—Rutherford, D. E.; Turnbull, H. W.

LANARK.

Glasgow Academy.—Clapton, N. L.
Glasgow: North Kelvinside Secondary School.—McLintock, W. G.
Glasgow: Royal Technical College.—Street, R. O.
Glasgow: St. Aloysius' College.—Vignaux, Rev. E.
Glasgow: St. Mungo's Academy.—Celestine, Rev. Bro.
Glasgow Tutorial College.—Muirhead, R. F.
Glasgow University.—McWhan, Dr. J.
Hamilton Academy.—Brownlee, R. W.
Harthill School.—Hutton, D.
Motherwell: Higher Grade R.C. Secondary School.—Deans, J.
Rutherglen Academy.—Macphie, D.

MIDLOTHIAN.

Barnton: Cargillfield School.—Ritchie, H. G.
Edinburgh Academy.—Hagopian, K. H.
Edinburgh: Daniel Stewart's College.—Hardie, J. A.
Edinburgh: Fettes College.—Edwards, J. S.

MIDLOTHIAN—Contd.

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Edinburgh: Moray House, Provincial Training College.—Taylor, W.
Edinburgh: St. George's School for Girls.—Hollinshead, Miss E.
Edinburgh University.—Gibb, D.; Ince, Dr. E. L.; Whittaker, Prof. E. T.
Leith Academy.—Borthwick, R.
Musselburgh: Loretto School.—Mermagen, P. H. F.; Mornard, A. J.

PERTH.

Forgandenny: Strathallan School.—Lewis, W. H.

RENFREW.

Paisley Technical College.—Findlay, R. F.

ROXBURGH.

Kelso High School.—Stewart, J. W.

WIGTOWN.

Stranraer High School.—Wallace, D. M.

NORTHERN IRELAND.

ANTRIM.

Belfast: Campbell College.—Ricketts, W. J.
Belfast: Richmond Lodge:—Funston, Miss M. F.
Belfast: Queen's University.—Cooper, Dr. R.; McCrea, Prof. W. H.; Todd, J.
Belfast: Royal Belfast Academical Institution.—MacDonald, A.

ARMAGH.

Lurgan Technical Institute.—Hall, T. W.

LONDONDERRY.

Londonderry: Foyle College.—Davidson, J.
Londonderry: Magee University College.—Guthrie, Prof. W. G.

IRISH FREE STATE.

Dublin: Blackrock Training College.—Ryan, Miss C.
Dublin: College of St. Columba.—Willis, Dr. S. J.
Dublin: Trinity College.—Rowe, C. H.

ISLE OF MAN.

Douglas High School for Boys.—Clarke, E. J.
Douglas High School for Girls.—Wilson, Miss G. M.

CHANNEL ISLANDS.

Guernsey: Elizabeth College.—Thompson, H. J.
Jersey: Victoria College.—Rowley, J. S.

AUSTRALIA.

NEW SOUTH WALES.

Petersham: Fort Street Boys' High School.—Chrismas, C. H.
Sydney: Metropolitan Business College.—Shearman, D. J.
Sydney, Newtown: Teachers' College.—Meldrum, H. J.
Sydney, North: Boys' High School.—Andersen, P. N. W.; Haron, T. K.
Sydney, North: Sydney Church of England Grammar School.—Robson, L. C.
Sydney: St. Joseph's College.—Liguori, Rev. Brother.
Sydney University.—Carslaw, Prof. N. S.; Thorne, H. H.; Wellish, Prof. E. M.
Wahroonga: Knox Grammar School.—Needham, J. S.
Waverley: Christian Brothers' College.—O'Gorman, Rev. Bro.

QUEENSLAND.

Brisbane Boys' Grammar School.—Stephenson, S.
Brisbane Industrial High School, Central Technical College.—Hennessey, F. A. C.
Brisbane Teachers' Training College.—McGovern. P. B.
Brisbane: University of Queensland.—McCarthy, J. P.; Raybould, Miss E. H.; Simonds, Prof. E. F.
Ipswich Boys' Grammar School.—Kerr, R. A.
Ipswich Girls' Grammar School.—Cribb, Miss E. M. B.
Southport: St. Kilda's School.—McCulloch, Miss M.
Toowoomba Grammar School.—Leadbeater, J. G.

SOUTH AUSTRALIA.

Adelaide: King's College.—Smith, K. W. A.
Adelaide, St. Peters: Collegiate School of St. Peter.—Symons, L. A. G.
Adelaide University.—Wilton, Prof. J. R.

VICTORIA.

Geelong: The Hermitage.—Peterson, Mrs.
Melbourne: Church of England Girls' Grammar School.—Waddell, Miss W.
Melbourne, East: Presbyterian Ladies' College.—Gibbons, Miss D. M.
Melbourne Technical College.—Allen, J. M.
Melbourne University.—Cherry, Prof. T. M.
Melbourne: University High School.—Syer, F. J. D.
Melbourne University: Ormond College.—Picken, D. K.
Parkville: University High School.—Sharman, M. S.
Prahran College.—Laing, Miss A. S.
Toorak: St. Kevin's College.—Marlow, Rev. Brother.

WESTERN AUSTRALIA.

Perth: University of W. Australia.—Weatherburn, Prof. C. E.

CANADA.

ALBERTA.

Edmonton: University of Alberta.—Sheldon, Prof. E. W.

MANITOBA.

Winnipeg: St. John's College School.—Maskell, F. G. B.

ONTARIO.

Toronto University.—Synge, Prof. J. L.

QUEBEC.

Lennoxville: Bishop's College.—Home, M.; Richardson, A. V.

INDIA.

Amraoti: King Edward College.—Pandy, Prof. K. D.
Bangalore: Bishop Cotton Girls' School.—Waller, Miss R. M.
Benares Hindu University.—Narlikar, Prof. V. V.
Bombay: Princess' High School for Girls.—Kharas, S. P.
Cawnpore, Nawab-Ganj: Sanatana Dharma College.—Bahadur, K.
Jodhpur Technical College.—Fergusson, F. F.
Jubbulpore: Robertson College.—Balekar, S. B.
Kurseong: Victoria School.—Staynor, E. V.
Mysore: Maharajah's College.—Ayyangar, A. A. K.
Poona: Sir Parashurambhan College.—Godbole, Prof. M. S.
Raipur: Rajkumar College.—Kapur, J. B. L.
Surat: Maganlal Thakordas Balmukunddas College.—Shah, Prof. N. M.
Vepery: St. Christopher's Training College.—Stokes, Miss E. M.

NEW ZEALAND.

Auckland Grammar School.—Driver, E. H.
Auckland: University College.—Forder, Prof. H. G.
Dunedin: Otago Boys' High School.—Martyn, W. J.
Gore High School.—Patterson, D.
Nelson College.—Smith, W. A. C.
Wellington East Girls' College.—Bell, Miss C. S.
Wellington: Victoria University College.—Miles, F. F.

SOUTH AFRICA.

BASUTOLAND.

Morija Training Institution.—French, G.

CAPE PROVINCE.

Capetown: South African College High School.—Dick, R. H.
Capetown University.—Crawford, Prof. L.; Skewes, S.
East London: Girls' High School.—Donald, Miss E. M.
Grahamstown: Victoria Boys' High School.—Wiles, C. H.

NATAL.

Durban High School.—Oberlé, Z. J.
Pietermaritzburg: Girls' Collegiate School.—Lear, Miss M.
Pietermaritzburg: Government Training College.—Reid, A.

ORANGE FREE STATE.

Bloemfontein: University College of the Orange Free State.—Arndt, Dr. J. G. A.

SOUTHERN RHODESIA.

Marandellas: Ruzawi School.—Grinham, R.

TRANSVAAL.

Johannesburg: Athlone High School.—Bovet, A.
Johannesburg: University of the Witwatersrand.—Dalton, Prof. J. P.
Johannesburg: St. John's College.—Clarke, Rev. S. H.; Harison, E. L.
Potchefstrom: Boys' High School.—Tyers, F. G.

BRITISH EAST AFRICA.

Uganda, Kampala: Makerere College.—Marriott, J. W. F.

BRITISH WEST INDIES.

Barbados: Harrison College.—Haskell, H. N.
Jamaica: Munro College.—Carter, H.

MALTA.

St. Edward's College.—Arkell, D. J.

STRAITS SETTLEMENTS.

Singapore: St. Andrew's School.—Koh, Eng Kwang.

UNITED STATES.

ILLINOIS.

Macomb: W. Illinois State Teachers' College.—Schreiber, Prof. E. W.
Peoria: Bradley Polytechnic Institute.—Comstock, C. E.

NEW HAMPSHIRE.

Exeter: Phillips Exeter Academy.—Wood, F. J.

NEW JERSEY.

Montclair: State Teachers' College.—Mallory, V. S.
Princeton University.—Wedderburn, Prof. J. H. M.

NEW YORK.

New York City: Columbia University.—Reeve. Prof. W. D.; Smith, Prof. D. E.

PENNSYLVANIA.

Kis-Lyn: Luzerne County Industrial School.—Johnson, C. F.

RHODE ISLAND.

Providence: Brown University.—Archibald, Prof. R. C.

CHINA.

Hong Kong: C.M.S. Heep Yunn School.—Pope, Miss B. M.
Peiping: Yenching University.—Hancock, Miss E. M.

EGYPT.

Cairo: Sanieh Secondary School.—Tawadrous, G.

FRANCE.

Paris: Collège de France.—Hadamard, Prof. J.
Paris: La Sorbonne.—Borel, Prof. E.
Paris: Lycée Louis-le-Grand.—Minois, S.

ITALY.

Genoa University.—Loria, Prof. G.

MALAYA.

Perak: Anderson School.—Cheow, U. K.

PALESTINE.

Haifa: Hebrew Secondary School.—Weich, S.
Haifa: St. Luke's School.—Semple, Rev. S. H.

SWITZERLAND.

Champ Fleuri, Glion: English Preparatory School.—Stephenson, Capt. H. P.

SYRIA.

Beirut: American University.—Jurdak, M. H.

Local Branches.

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Mrs. E. WARDLEY SMITH.

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No. of Junior Members, 1.

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No. of Members, 5. No. of Associates, 32.

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Vice-Chairman:
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Hon. Secretary:
Mr. S. MOSES.

Committee:
Professor W. E. H. BERWICK, Mr. E. G. PHILLIPS, Mr. S. MOSES.

No. of Members, 4. No. of Associates, 14.

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SOUTH-WEST WALES BRANCH.

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Chairman.
Mr. J. GREY MORGANS, The Grammar School, Swansea.

Hon. Treasurer:
Mr. M. CHAPPLE, Glanmôr Secondary School, Swansea.

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Mr. T. G. FOULKES, The Grammar School, Swansea.

Committee.
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